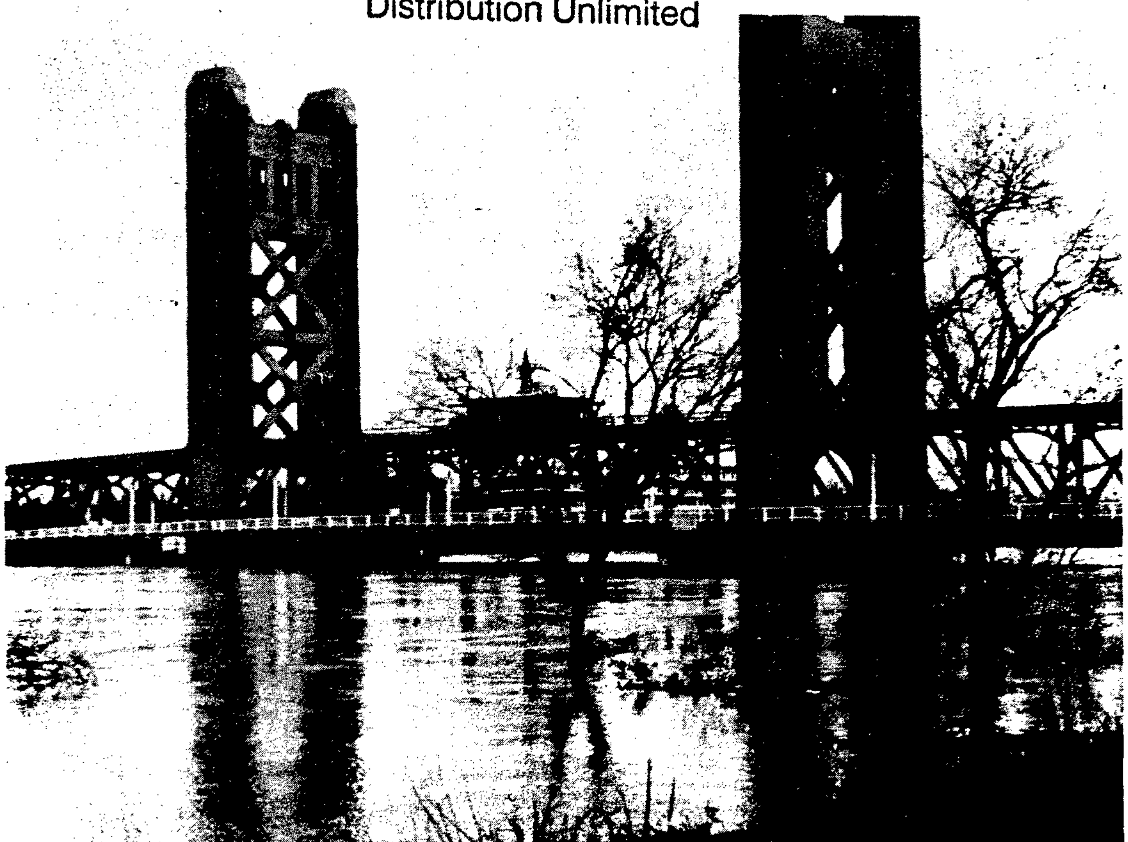
Final Feasibility Report and Final Environmental Impact Statement/ Final Environmental Impact Report

February 1992

Sacramento Metropolitan Area California



US Army Corps
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Sacramento District
South Pacific Division

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1. Little Dell Lake, Salt Lake City Streams, Utah, Embankment Criteria and Performance Report, August 1994
2. Caliente Creek Stream Group Investigation California, Draft Feasibility Report, June 1987
3. Fanchier Creek Dam Fresno, California, Embankment Criteria and Performance Report, July 1994
4. Sacramento Metropolitan Area California: Final Feasibility Report and Final Environmental Impact Statement/Final Environmental Impact Report, February 1992
5. Geologic and Seismologic Investigation, Hidden and Buchanan Dams, Hensley Lake and Eastman Lake, Fresno and Chowchilla Rivers, California, December 1988
6. Sacramento River Flood Control Project, California, Mid-Valley Area, Phase III, Design Memorandum, Volumes 1 and 2, August 1995
7. Reconnaissance Report Yolo Bypass, California, March 1992
8. Provo and Vicinity, Utah, General Investigation Reconnaissance Report, April 1997
9. Sacramento-San Joaquin Delta, California, Draft Feasibility Report and Draft Environmental Impact Statement, October 1982

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TABLE OF CONTENTS

PLATES

APPENDICES

TABLES

FIGURES

SACRAMENTO METROPOLITAN AREA, CALIFORNIA

EXECUTIVE SUMMARY

Introduction

This Feasibility Report and Environmental Impact Statement/Environmental Impact Report (FR/EIS/EIR) describes the results of studies on flooding problems along the Sacramento River and Yolo Bypass from the Sacramento Weir downstream to an area just south of Freeport (see Plate A). The study area is located along the Sacramento River, in Yolo County, California, and is not included in the American River Watershed Investigation. The report also identifies a Selected Plan to reduce the potential flood threat to the West Sacramento area. The report includes a main report, EIS/EIR and appendices. The non-Federal sponsor of the study is the State of California. Public and agency comments on the draft report and the proposed plan have been solicited in the draft report and have been used to develop the Selected Plan. The report will be submitted to the Congress for construction authorization.

Study Authorization

The basic authority for the study is provided in the Flood Control Act of 1962 (Public Law 87-874), which directs the Corps of Engineers to study flood control problems in the Sacramento River basin and other streams in northern California.

Flood Problem

In February 1986, major storms in northern California caused record floodflows in the Sacramento River Basin. Significant flood damage resulted, and it is estimated that if the storms had lasted much longer, major levee failure would have been likely. Resulting flooding could have caused loss of life and billions of dollars in damages in the basin.

In the study area, riverflows and local tributary inflows exceeded design levels throughout the flood control system. Photographs of Interstate 80 and the Yolo Bypass during the February 1986 flood show the high water levels and their proximity to West Sacramento (see Plate B). Prior to the 1986 flood, West Sacramento was thought to have in excess of 100-year level of flood protection. However, based on stage-frequency relationships, the frequency of the 1986 flood for the study area was estimated to be approximately 70 years for both the Yolo Bypass and the Sacramento River. Currently, about 30,000 people are at risk from flooding in the West Sacramento area, and there is an estimated $1.2 billion in damageable property in the flood plain.

Flood plain studies in 1988 for the Federal Emergency Management Agency concluded that virtually all of the study area is within the 100-year flood plain. The West Sacramento area is temporarily exempted from implementing the restrictions associated with the National Flood Insurance Program building moratorium. When the restrictions are implemented in November 1992, there could be a significant impact on future development in the area.

Flood Control Alternatives

Flood control alternatives were formulated by (1) identifying and evaluating a variety of flood control measures and (2) developing final alternatives based on feasible measures. Potential measures included modifying existing weirs, modifying existing levees, diversion facilities, storage facilities, deepening or enlarging channels, and nonstructural measures. The only measure that was technically, economically and environmentally feasible was to modify existing levees.

As the final alternatives were developed, it was assumed that the flood control improvements proposed in the Sacramento River Flood Control System Evaluation (System Evaluation) and the American River Watershed Investigation would be in place under with- and without-project conditions for this study. The System Evaluation includes structural modifications to the flood control levees to return them to their original design. The levee embankment of the Sacramento River Flood Control Project were originally designed based on 1) a design discharge, 2) a design water surface, and 3) a minimum freeboard requirement above the design water surface. A flood frequency was never assigned to the original design. Details of these design water surface elevations can be found in the Sacramento River Flood Control System Evaluation, Initial Appraisal Report (January 1991). Therefore, it was assumed that the levees in the study area would be structurally stable. The Selected Plan for the American River Watershed Investigation consists of a 200-year, peak-flow, flood-control-only dam located near Auburn on the North Fork of the American River, levee and channel modifications around the Natomas area, and a detention basin in northeast Natomas near Pleasant Grove Canal.

The final alternatives include:

No Action. - Under this alternative, the Federal government would take no action toward implementing a specific flood control plan in the study area. No action also includes flood control improvements proposed in the American River Watershed Investigation.

100-Year Plan. - This alternative would provide a 100-year level of protection for the West Sacramento area. The plan

consists of raising portions of the levees around the city of West Sacramento. The proposed levee work would consist of raising existing levees a maximum height of 4.2 feet along 5,800 linear feet of the south levee of the Sacramento Bypass and 4.7 feet along 24,800 linear feet of the Yolo Bypass east levee.

200-Year Plan. - This alternative would provide a 200-year level of flood protection for the West Sacramento area. The features of this plan are the same as the 100-year plan except that levees would be raised a maximum height of 4.8 feet and 5.3 feet along the respective levees.

400-Year Plan. - This alternative would provide a 400-year level of flood protection for the West Sacramento area. The features of this plan are the same as the 100-year plan except that levees would be raised a maximum height of 5.0 feet along 5,800 linear feet of the south levee of the Sacramento Bypass and 5.5 feet along 24,800 linear feet of the Yolo Bypass east levee.

Each of the alternatives would include features to offset adverse environmental impacts. First cost estimates for the 100-, 200- and 400-year plans are $15.9, $18.1 and $18.4 million, respectively. Average annual equivalent benefits are estimated to be $7.2, $8.9 and $9.8 million, providing net benefits of $5.6, $7.1 and $7.9 million for the 100-, 200- and 400-year plans, respectively. The plan that maximizes the net benefits (National Economic Development [NED] plan) is the 400-year plan.

Selected Plan

The non-Federal sponsor, the State of California, supports the NED plan as the Selected Plan. Based on the analyses and local support, the NED Plan was chosen as the Selected Plan.

The primary features of the Selected Plan are:

Flood Control

- Raise a total of 5.7 miles of existing levees around West Sacramento. This includes raising 1 mile of the south levee of the Sacramento Bypass a maximum of 5.0 feet and 4.7 miles of the Yolo Bypass east levee a maximum of 5.5 feet.

- Levee raising will be landward for levees on the south side of the Sacramento Bypass and the Yolo Bypass south to the Southern Pacific Railroad to the Sacramento Ship Channel. Levee raising would be on both the landward and waterward sides of the Yolo Bypass east levee between the Sacramento Bypass and Southern Pacific Railroad.

- Obtain material from two borrow sites, one within the Sacramento Bypass and one owned by the Sacramento-Yolo Port District.

- Place a 12-inch blanket of riprap on the raised levees.

- Install a flood gate at the Southern Pacific Railroad crossing along the east side of the Yolo Bypass.

Environmental Mitigation

- Create and manage 39.4 acres of wetland and 13.1 acres of upland grassland habitat.

- Reseed 150 acres of upland grassland habitat.

Features of the Selected Plan are shown on Plate C. The Selected Plan would provide 400-year level of flood protection to the West Sacramento area. The plan would reduce the average annual equivalent flood damages from about $10 million to about $1.7 million. The potential hydraulic impacts associated with the levee-raising alternatives were analyzed in terms of changes in existing depth, duration, and frequency of flooding for adjacent and downstream areas. The analysis indicated that there would be no significant hydraulic impacts caused by the Selected Plan.

The Selected Plan was developed to avoid and/or minimize (to the greatest extent possible) adverse environmental impacts in the study area. Unavoidable impacts would include the permanent loss of 11.9 acres of wetlands and 29.0 acres of upland grassland and temporary loss of 149.8 acres of upland grassland. The permanent impacts would be fully mitigated by creating and managing 39.4 acres of wetlands and 13.1 acres of uplands habitats on a 70-acre parcel in the Yolo Bypass immediately south of the Sacramento Bypass. The temporary loss of upland grassland would be offset by reseeding the area.

The total first cost of the Selected Plan is estimated at $17.4 million (October 1991 price levels). The decrease in cost from the preliminary 400-year alternative to the Selected Plan ($18.4 to $17.4 million) was due to the selection of a less expensive environmental mitigation site and refinements in detailed cost estimates for the plan. The total annual costs of the plan are estimated at $1.7 million including $20,000 for operation and maintenance and replacement costs. Potential benefits of the Selected Plan include inundation reduction, location, intensification, and flood insurance program benefits. The average annual equivalent benefits at an interest rate of 8-3/4 percent are estimated at $9.8 million (includes $1.3 million in location benefits), yielding a benefit-to-cost ratio of 5.7 to 1.0. Tables A and B show the first and annual costs and benefits

and a breakdown of the costs for the Selected Plan among the Federal/non-Federal interests.

Cost Sharing

Current Federal regulations require non-Federal participation in the financing of projects. In accordance with the Water Resources Development Act of 1986, the non-Federal sponsor will provide lands, easements and rights-of-way for construction and maintenance of the project, a cash contribution of 5 percent of the total project cost, and additional cash (if necessary) to bring the non-Federal share to a minimum of 25 percent of the total project costs. Based on these requirements, the total non-Federal share of the project cost is $4,323,000. In addition, the non-Federal sponsor will be responsible for the operation and maintenance of the project.

Local Support

There is strong local support for a plan that would provide a high level of flood protection to the area, while minimizing any potential adverse environmental impacts. The State of California, as well as County, City, and other local agencies, are actively cooperating in the development of an acceptable plan.

Conclusions

A serious flood threat exists in the West Sacramento area. Technical and economic analyses indicate that there are feasible flood control plans that could alleviate this flood threat. Based on these analyses and input from the local sponsor, a plan has been selected that includes levee raising around the West Sacramento area. This plan provides a 400-year level of flood protection and environmental mitigation for potential impacts. The Selected Plan assumes the American River 200-year flood control-only dam is in place under the with- and without project conditions. If the American River project is not constructed, the proposed Selected Plan for Sacramento Metropolitan Area Study is still feasible and will provide the area of West Sacramento with at least a 150-year level of flood protection.

TABLE A

ECONOMIC SUMMARY OF SELECTED PLAN

Annual Costs	
Total First Costs	$17,400,000
Interest During Construction	1,600,000
Total First Investment	19,000,000
Interest Rate	8.875 %
Analysis Period (years)	100
Annual Costs	1,680,000
O,M & R Costs	20,000
Total Annual Costs	$1,700,000

Item	$ Millions
Annual Cost	1.7
Annual Benefits	9.8
Net Benefits	8.1
B/C Ratio	5.7

TABLE B

SELECTED PLAN
SUMMARY OF FIRST COSTS

	Federal	Non-Federal	Total
Lands and Damages	$180,000 1/	$1,700,000	$1,880,000
Relocations	---	15,000	15,000
Fish & Wildlife Facilities	2,400,000	---	2,400,000
Levees	10,200,000	---	10,200,000
Cult Res Preservation 2/	131,000	---	131,000
Engineering and Design	1,660,000	5,000	1,665,000
Construction Management	1,130,000	2,000	1,132,000
Subtotal	$15,701,000	$1,722,000	$17,423,000
Non-Fed Cash Contribution	-2,601,000	+2,601,000	
Project First Cost	$13,100,000	$4,323,000	$17,423,000

1/ Federal administrative costs for non-Federal land acquisition.
2/ Cultural Resources Preservation costs associated with mitigation and/or data recovery up to one percent of the total Federal costs are not subject to cost sharing.

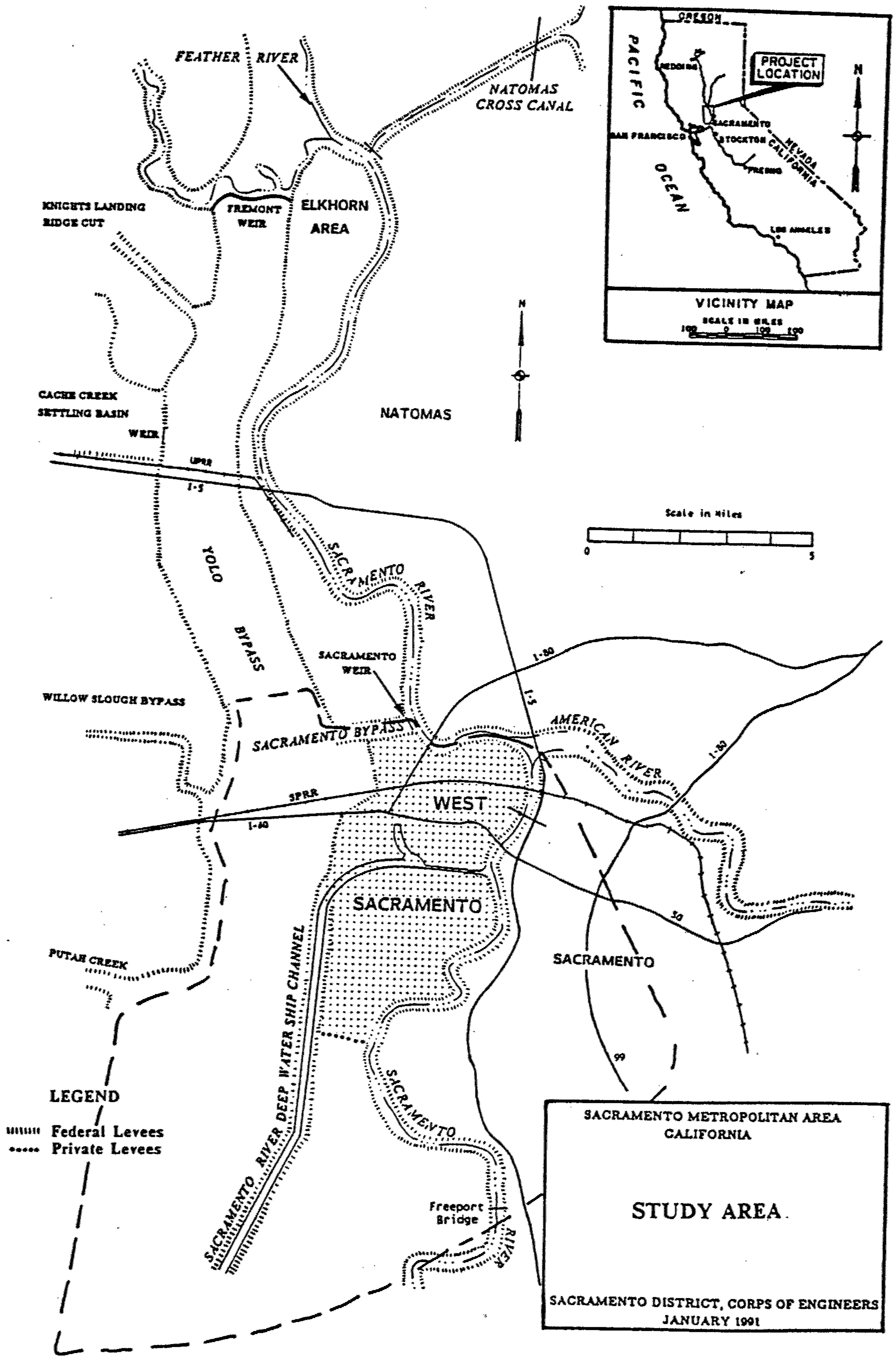
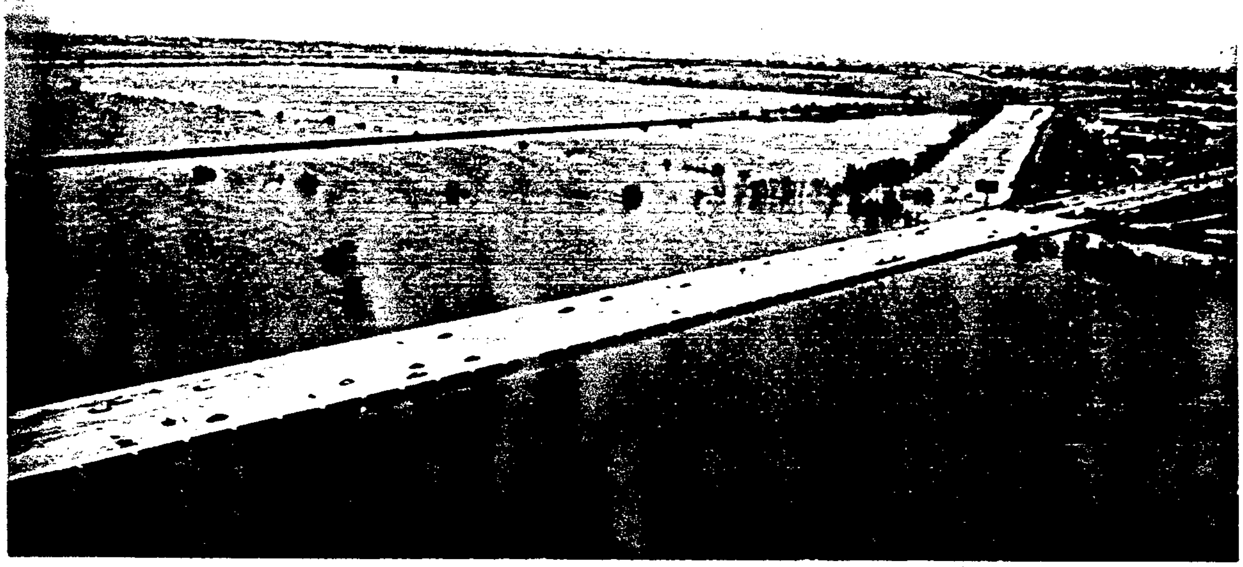
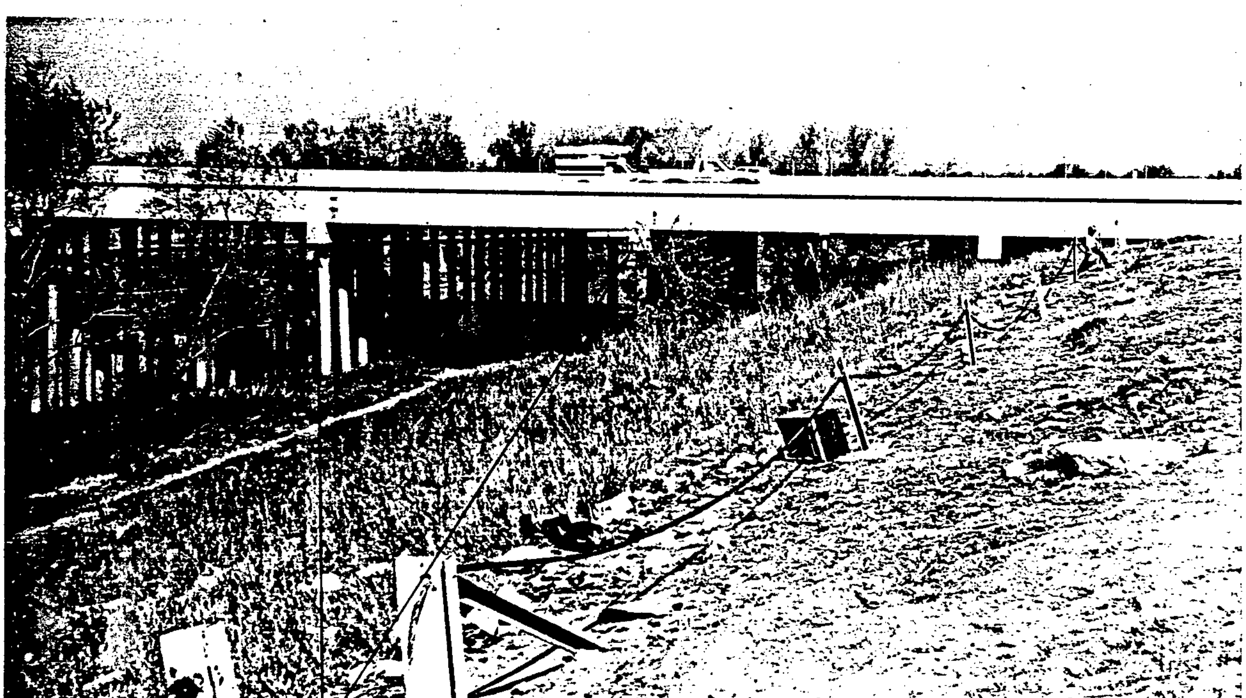

FEATHER RIVER
NATOMAS CROSS CANAL
KNIGHTS LANDING RIDGE CUT
FREMONT WEIR
ELKHORN AREA
CACHE CREEK SETTLING BASIN
WEIR
NATOMAS
UPRR
I-5
YOLO BYPASS
SACRAMENTO RIVER
SACRAMENTO WEIR
WILLOW SLOUGH BYPASS
SACRAMENTO BYPASS
I-80
AMERICAN RIVER
SPRR
WEST
SACRAMENTO
50
PUTAH CREEK
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
99
LEGEND
Federal Levees
Private Levees
Freeport Bridge
Scale in Miles
0
5
N
VICINITY MAP
OREGON
PACIFIC OCEAN
PROJECT LOCATION
REDDING
SACRAMENTO
SAN FRANCISCO
STOCKTON
NEVADA
CALIFORNIA
FRESNO
LOS ANGELES
SACRAMENTO METROPOLITAN AREA
CALIFORNIA
STUDY AREA
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1991

PLATE A



EAST LEVEE OF YOLO BYPASS AT INTERSTATE 80 DURING FEBRUARY 1986 FLOOD.



HIGH WATER DURING FEBRUARY 1986 FLOOD WAS NEARLY TOUCHING BOTTOM OF TRANSVERSE BEAMS OF INTERSTATE 80 NEAR EAST LEVEE OF YOLO BYPASS.

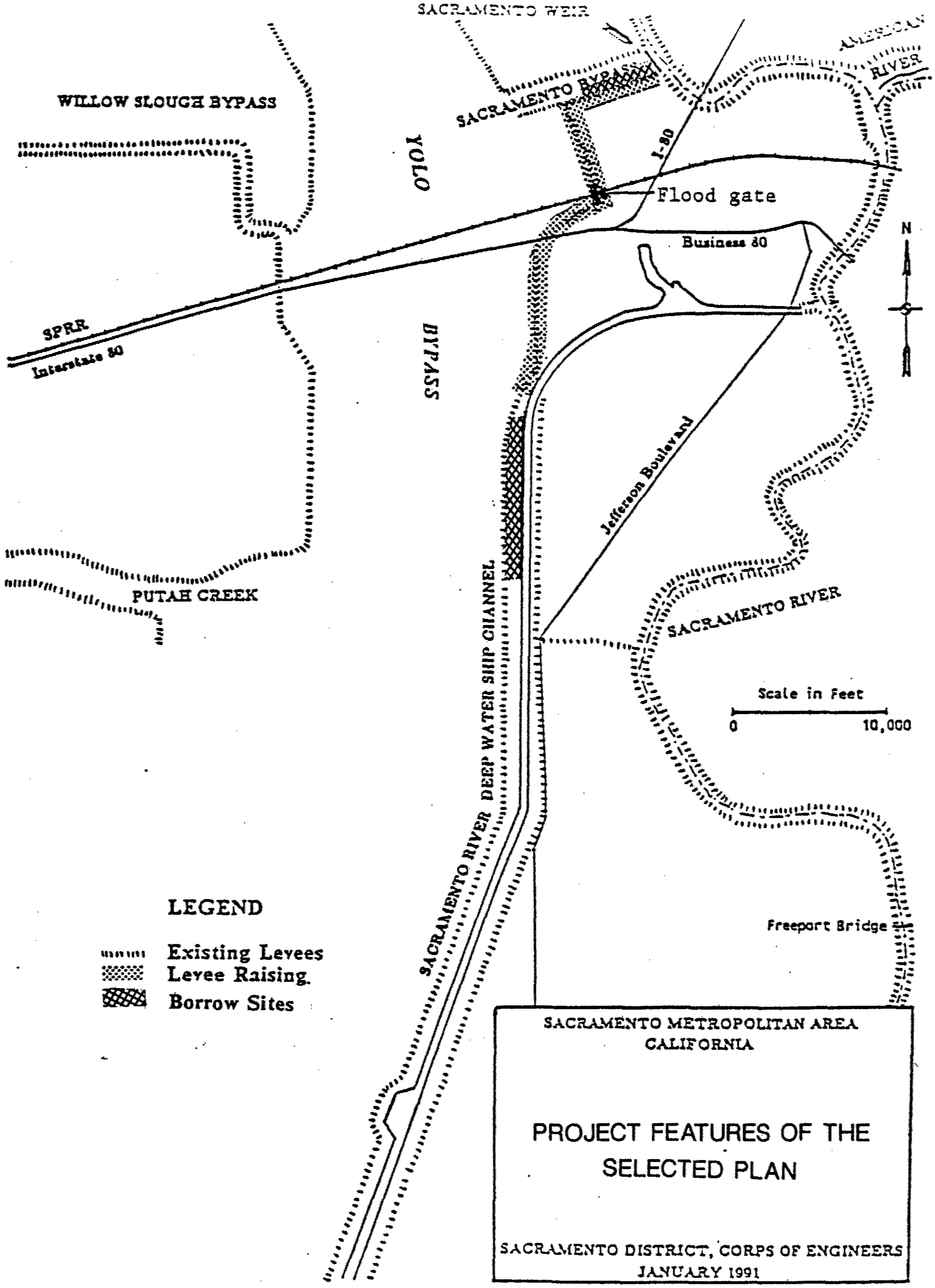

SACRAMENTO WEIR
AMERICAN RIVER
WILLOW SLOUGH BYPASS
SACRAMENTO BYPASS
YOLO BYPASS
I-80
Flood gate
Business 80
SPRR
Interstate 80
Jefferson Boulevard
PUTAH CREEK
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
SACRAMENTO RIVER
Scale in Feet
0
10,000
Freeport Bridge
N
LEGEND
Existing Levees
Levee Raising
Borrow Sites
SACRAMENTO METROPOLITAN AREA
CALIFORNIA
PROJECT FEATURES OF THE SELECTED PLAN
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1991

PLATE C

CHAPTER I

INTRODUCTION

PURPOSE AND SCOPE

This feasibility study was undertaken to (1) evaluate the need for additional flood protection in the Sacramento Metropolitan area that was not included in the American River Watershed Investigation, (2) identify alternatives to increase the level of flood protection, and (3) determine the Federal interest in these alternatives based on costs, benefits, environmental impacts, and local interest and support. The study area includes the developed areas along the Sacramento River and Yolo Bypass from the Sacramento Weir, downstream to an area just south of Freeport and from the west levee of the Sacramento River to the east levee of the Yolo Bypass (see Plate 1).

STUDY AUTHORITY

The U.S. Army Corps of Engineers (Corps) conducted the Sacramento Metropolitan Area Study under the authority of the Flood Control Act of 1962 (Public Law 87-874), a portion of which reads as follows:

> The Secretary of the Army is hereby authorized and directed to cause surveys for flood control and allied purposes, including channel and major drainage improvements, and floods aggravated by or due to wind or tidal effects, to be made under the direction of the Chief of Engineers, in drainage areas of the United States and its territorial possessions, which include the following named localities: Sacramento River Basin and streams in northern California draining into the Pacific Ocean for the purposes of developing, where feasible, multi-purpose water resource projects, particularly those which would be eligible under the provisions of Title III of Public Law 85-500.

STUDY PARTICIPANTS AND COORDINATION

The Corps, Sacramento District, conducted the study, formulated and evaluated flood control alternatives, and prepared this report. Study activities were coordinated with the non-Federal sponsors and local interests and other agencies, who contributed significant information on existing and future development, environmental resources, and project operation and maintenance activities within the study area and cooperated in developing the Selected Plan.

The State of California State Reclamation Board (Board) is the local sponsor for the study; agencies participating as cost-sharing partners with the Board include the City of West Sacramento, Yolo County, Yolo County Flood Control and Water Conservation District, and Reclamation Districts 900, 537, 2068, and 811. In addition to sharing the study costs, the Board provided levee crown surveys, hydrologic and maintenance data on the Fremont and Sacramento Weirs, and real estate acquisition estimates. The Board also assisted the Corps in public meetings, which were held to gather comments from and provide information to local interests on the study. A draft Environmental Impact Statement/Environmental Impact Report (DEIS/EIR) was coordinated for public and agency review between October and December 1991. Two public workshops and a public hearing were held in December 1991. Comments were received on the draft report, and these comments were considered in the final revision of this document.

In addition to the Board and other cost-sharing sponsors, the Corps also coordinated study activities with the following agencies and local interests, who provided documents and data for various stages of the investigation and participated in public meetings.

Federal Agencies

Bureau of Indian Affairs
Bureau of Reclamation
Environmental Protection Agency
Fish and Wildlife Service
Geological Survey
National Marine Fisheries Service
Soil Conservation Service

California State Agencies

Department of Fish and Game
Department of Transportation
Department of Water Resources
Reclamation Board
State Historic Preservation Officer
State Lands Commission

Local Agencies and Organizations

County of Sacramento
Southern Pacific Transportation Company
Yolo Basin Foundation
Yolo Basin Working Group
Yolo County Office of Emergency Services
Yolo-Solano Air Pollution Control District
Yolo-Solano Flood Control Task Force

PRIOR STUDIES AND REPORTS

Prior reports of primary importance to the Sacramento Metropolitan Area Study are summarized in Table 1. Each report provided background information on water resources and opportunities in the study area.

TABLE 1

WATER RESOURCES REPORTS ON THE SACRAMENTO RIVER

AGENCY	TITLE AND DATE	PURPOSE
Federal U.S. Army Corps of Engineers, Sacramento District	Definite Project Report, Sacramento River Deep Water Ship Channel Project, Sacramento River, California, July 1949.	Described the adopted project plan, with details of the basis of design and cost estimates.
	Cache Creek Basin, California, Feasibility Report and Environmental Statement for Water Resources Development, February 1979.	Investigated flood, sediment and related water resource problems and needs of the Cache Creek basin. Described and evaluated various alternatives to help solve these problems.
	Sacramento River and Tributaries, Bank Protection and Erosion Control Investigation, Sediment Transport Studies, rev. August 1983.	Described and evaluated potential erosion control measures that could be used in the Sacramento River basin. Determined sediment deposition in Yolo and Sutter Bypasses.
	Special Study on the Lower American River, California, March 1987.	Reviewed and updated the hydrology of the American River, determined areas of potential flooding, computed flood damages and benefits, and reviewed alternative measures for flood control.
	Report on the February 1986 Floods in Northern California and Northwestern Nevada, January 1987.	Documented the hydrologic, physical and economic damage data of the February 1986 rainfloods that occurred in Northern California and Northwestern Nevada.
	Information Paper, American River Watershed, California, November 1987.	Summarized the results of the American River Watershed Reconnaissance Study.
	American River Watershed Investigation, California, Reconnaissance Report, January 1988.	Defined flood problems in the watershed. Formulated and evaluated alternative plans for flood control along the lower American River and in the Natomas area.
	American River Watershed Investigation, California, Draft Feasibility Report, December 1991.	Defined flood problems in the American River Watershed. Formulated and evaluated detailed alternative plans for flood control along the lower American River and in the Natomas area. Selected Plan is the 200-year flood-control-only dam on the American River.
	Sacramento River Deep Water Ship Channel, California, Supplement No. 1 to the General Design Memorandum of March 1986, May 1988.	Investigated redesign of the ship channel in order to reduce project costs. Emphasized channel width requirements, dredged material quantities and disposal areas, and operation and maintenance considerations.

TABLE 1 (continued)

WATER RESOURCES STUDIES AND REPORTS ON THE SACRAMENTO RIVER

AGENCY	TITLE AND DATE	PURPOSE
Federal U.S. Army Corps of Engineers, Sacramento District	Sacramento River Deep Water Ship Channel, California, Supplement No. 1 to the General Design Memorandum of March 1986, May 1988.	Investigated redesign of the ship channel in order to reduce project costs. Emphasized channel width requirements, dredged material quantities and disposal areas, and operation and maintenance considerations.
	Sacramento River Flood Control System Evaluation, Initial Appraisal Report - Sacramento Urban Area, May 1988.	Investigated the structural integrity of about 110 miles of Sacramento River Flood Control Project levees in the Sacramento urban area.
	Sacramento River Flood Control System Evaluation, Initial Appraisal Report - Marysville/Yuba City Area, January 1990.	Investigated the structures integrity of about 134 miles of Sacramento River Flood Control Project levees in the Marysville ville/Yuba city area.
	Sacramento River Flood Control System Evaluation, Initial Appraisal Report - Mid-Valley Area, January 1991.	Investigated the structural integrity of about 240 miles of Sacramento River Flood Control project levees in the Mid-Valley area.
Federal Emergency Management Agency	Sacramento Flood Insurance Study, November 1989.	Prepared a Flood Insurance Rate Map showing the 100-year (FEMA base) flood plain. Includes the American River downstream of Nimbus Dam, North and South Natomas, and the Sacramento River from the Natomas Cross Canal downstream to Freeport.
	West Sacramento Flood Insurance Study, March 1990.	Prepared a Flood Insurance Rate map showing the 100-year (FEMA base) flood plain. Includes the west side of Sacramento River from Fremont Weir downstream to the southern limit of West Sacramento.
U.S. Geological Survey	Profile of Sacramento River, Freeport to Verona, California, Flood of February 1986, Open-File Report 88-82, 1988.	Documented the February 19 and 20, 1986, peak water-surface profile of the Sacramento River, peak discharges of the Sacramento Sacramento and American Rivers, and data for five gaging stations located in a 33-mile reach between Freeport and Verona.
State of California	Report to the Trustees of the American River Flood Control District on Flood Control of the American River, December 1929.	Discussed flooding problems along the American River, particularly the March 1928 flood. Presented designs, costs and benefits of a plan to alleviate future flooding.

TABLE 1 (continued)

WATER RESOURCES STUDIES AND REPORTS ON THE SACRAMENTO RIVER

AGENCY	TITLE AND DATE	PURPOSE
Local		
County of Yolo	Multihazard Functional Plan, 1988.	Discussed procedures to be followed during various emergencies (including flooding and dam failure) in the county.
City of West Sacramento	General Plan, Background Report and Environmental Impact Report, Final Review Draft, March 1990.	Inventoried and analyzed existing social, economic and environmental conditions and trends in West Sacramento. Provided documentation for general plan policy.
	Emergency Plan, pending completion February 1992.	Discuss procedures to be followed during various emergencies (including flooding).
Private		
Frank Kochis	History of Development of the Sacramento River Flood Control Project, July 1969.	Presented a historical survey of the legal documents and political events leading to the construction and implementation of the Sacramento River Flood Control Project.
Ray Krone	Impacts of the Lighthouse Marina Project on Flood Flows, August 1986.	Evaluated the impacts of the Lighthouse Marina project on the capacity of the Sacramento and American Rivers to convey flood-flows.

CHAPTER II

STUDY AREA DESCRIPTION

EXISTING CONDITIONS

Existing Water Resources Projects

Sacramento River Flood Control Project. The Sacramento River Flood Control Project is a comprehensive system of levees, overflow weirs, outfall gates, pumping plants, leveed bypass floodways, overbank floodway areas, enlarged and improved channels, and dredging in the lower reach of the Sacramento River.

The project was authorized by the Federal Flood Control Act of 1917. Major reconstruction of a much smaller existing system began in 1918 and was sponsored by the Reclamation Board, State of California. Various components were completed between 1952 and 1958, and the active portion was completed in 1968. The project operates by containing potential floodwaters of various streams, river channels, and sloughs between levees, which protect against overbank flooding, and diverting these floodwaters into the Butte Basin and the Sutter and Yolo bypasses through a system of flood relief structures and weirs (see Plate 1). The project includes about 1,000 miles of levees including 170 miles of levees on the Feather River and tributaries that provide flood protection to the cities of Colusa, Gridley, Live Oak, Yuba City, Marysville, Sacramento, West Sacramento, Courtland, Isleton, Rio Vista, and numerous smaller communities; transcontinental railroads; feeder railroads; airport facilities; and about 800,000 acres of agricultural lands and many state and county highways. During its history, the project has prevented billions of dollars in flood damage.

American River Flood Control Project. The American River portion of the project consists of 10.8 miles of levee improvements along the south bank of the river and about 5.8 miles of improvements along the north bank. The south-bank levee extends from the mouth of the American River upstream to Mayhew Drain of Mayhew Road. The north-bank levee extend from the mouth of the American River upstream about 2.3 miles (in this reach, the north levee along the NEMDC contains the lower American), then about 3.5 miles upstream to the area near Cal Expo. These levees are considered capable of safely containing sustained flows of 115,000 cubic feet per second (cfs). The project also includes two pumping plants, which discharge storm drainage collecting inflow areas landside of the levee into the river. In conjunction with Folsom Lake, the levee permits design releases of 115,000 cubic feet per second (cfs) for flood control along the river downstream. The project was completed by the Corps in 1958 and is operated and maintained by the State of California.

Sacramento River Deep Water Ship Channel. The Sacramento River Deep Water Ship Channel (Ship Channel) is a 43-mile-long channel formed by widening and deepening existing channels from the Suisun Bay to Rio Vista and by excavating a new channel from that point to Lake Washington in West Sacramento. The channel project also includes a triangular harbor and turning basin in Lake Washington and a 1.5-mile shallow-draft barge canal with a 86-foot-wide and 600-foot-long navigation lock between the harbor and the Sacramento River.

The barge canal and lock, which has a 4-foot lift at normal pool elevation, provides for the transfer of barges between the two different water surface elevations. A 135-foot-span, single leaf combination highway and railroad bascule bridge crosses that canal at the harbor end of the lock. The lock is currently in "caretaker" status under Corps jurisdiction and is permanently closed except in emergency or special situations. Although State and local agencies have expressed interest in reactivating the lock, future operation is uncertain. The channel project was completed in 1963, with the Sacramento-Yolo Port District as the local sponsor. The Corps completed a Feasibility Report dated July 1980, which presented the results of an investigation conducted to determine the need for deeper draft channels to the Port of Sacramento to improve the transportation of commodities and to improve the safety and usefulness of existing channels. The recommended plan provided for enlarging the Suisun Bay and Sacramento River Deep Water Channels from New York Slough to the Port of sacramento, from the existing 30 foot channel to 35 feet. Dredging from River Mile 41.5 to 35 was completed in April 1991. In addition, the channel would be widened as necessary to maintain navigation safety. Water quality monitoring is also part of the recommended plan, salinity monitors were installed in April 1991. The improvement project requires 45 acres of land for the establishment of wetland habitat and 156 acres of land for upland habitat to mitigate for losses of such habitat.

Central Valley Project. The Central Valley Project is a multiple-purpose development that stores and transfers surplus waters primarily from the Sacramento and Trinity River basins to the water-deficient lands of the San Joaquin River and Tulare Lake basins. The project, authorized in 1937, was constructed and is operated by the U.S. Bureau of Reclamation (USBR). Although the main function of the project is water supply, it also provides benefits to power, flood control, navigation, fish and wildlife, recreation, and water quality control. Physical features include dams and reservoirs, pumping plants, canals and generating facilities.

The main source of project water is Shasta Reservoir, completed in 1943, which stores 4.5 million acre-feet of water and reserves 1.3 million acre-feet of storage space during the flood season for flood control. A cooperative agreement between the USBR and the Corps regulates the operation of Central Valley Project reservoirs for flood control.

Folsom Dam is located on the main stem of the American River, 20 miles upstream from Sacramento near the city of Folsom, and consists of a concrete gravity main dam, wing dams, and eight earthfill dikes, creating a reservoir with a storage capacity of 1 million acre-feet. The Corps completed construction of Folsom Dam and Reservoir in 1956 and transferred operation and maintenance of the facilities to the USBR as part of the Central Valley Project. The project provides 400,000 acre-feet of authorized flood control space, 500,000 acre-feet of water for irrigation and municipal uses, and 500 million kilowatt-hours of hydroelectric power annually.

California State Water Project. - In 1959, the State Legislature enacted the California Water Resources Development Bond Act, which authorized the construction and operation of the State Water Project to balance California's water resources and water needs. State Water Project facilities include 23 dams and reservoirs, 8 powerplants, 22 pumping plants, and 684 miles of aqueducts.

The project's major feature is Oroville Lake, located 4 miles northeast of Oroville on the Feather River. Oroville Dam, which was completed in 1967 and is the highest earthfill dam in the United States, impounds a 3.5-million acre-foot reservoir, 750,000 acre-feet of which are reserved for flood control. Flood control operations are coordinated with New Bullards Bar Reservoir on the North Fork of the Yuba River, according to Corps regulations.

Local Levees. Several non-Federal levees in the Sacramento Metropolitan area, including road and railroad embankments that generally function as barriers to floodflows during major floods, could impact flood stages and flooded areas within the Sacramento area. The two significant private levees in the study area are (1) a 1.2-mile reclamation levee along the southern limit of West Sacramento, which connects the Sacramento River Flood Control Project levee on the east and the Yolo Bypass levee on the west and acts as a temporary barrier to potential floodwaters moving southward from West Sacramento and (2) an embankment located adjacent to the Port of Sacramento's south lock and barge canal, which provides a measure of flood control to the area of West Sacramento below the Port.

Drainage Facilities. A system of canals located within the areas protected by Sacramento River Flood Control Project and local levees collects and channels surface water runoff from rainfall, irrigation, and other sources into pumping stations located near the levee embankments. Water is then pumped through the levee embankments into the Sacramento River, Yolo Bypass, Ship Channel, and other tributaries that make up the Sacramento River Flood Control Project system.

Pumps are needed because water surface elevations on the Sacramento River and Yolo Bypass during major flood events are significantly higher than adjacent land surface elevations landward of the levees. During major storms, the pumps run at or near peak capacity to remove accumulated runoff since the sump areas for the various pump stations have limited capacity.

Reclamation Districts 537 and 900, with a peak pumping capacity of about 500 cfs, are primarily responsible for the interior drainage and pumping of surface water runoff within West Sacramento. Pumped water is diverted into the Sacramento Bypass, Yolo Bypass and the Ship Channel.

Emergency Preparedness Plans

Corps of Engineers. The Sacramento District's response to flood emergencies is comprised of three phases: (1) the Informational Phase, during which Corps hydrological staff is on a 24-hour information alert and begins a 24-hour liaison with State Flood Operations Center(s), (2) the Alert Phase, during which the Corps' Emergency Operations Center is activated and office and field personnel cooperate with emergency teams of affected State agencies in patrol and observation activities, and (3) the Mobilization Phase, during which the District furnishes or provides emergency assistance, including repairing levee breaks, placing riprap and other material along levees to prevent overtopping, constructing additional protective levees, and providing sandbags.

State of California. The State-Federal Flood Operations Center, in cooperation with the National Weather Service California-Nevada River Forecast Center, provides 24-hour monitoring and river information for early flood warnings to local, State and Federal agencies. The Center makes Federal-State forecasts of conditions and notifies individuals and agencies to begin mobilizing levee patrols, moving equipment and livestock, and evacuating flood plain residents.

At the same time, staff of the State and County Offices of Emergency Services monitor flood information and prepare emergency assistance. The Office of Emergency Services network includes fire departments, law enforcement agencies, and highway and road departments.

County of Yolo. The County of Yolo's multihazard emergency plan includes emergency procedures for flooding and dam failure. Each County agency has designated responsibilities during an emergency, and an emergency center provides information and coordinates activities. The City of West Sacramento is included in Yolo County's emergency plan, but is currently drafting its own plan, which it will operate in cooperation with the County plan.

Related Studies and Projects

Recent flood events in northern California exposed structural problems and identified the inability of existing flood control projects to provide critical flood protection in the area. The Sacramento Metropolitan Area Study is one of eight current Corps studies and projects to resolve flood problems in the greater Sacramento area. The other seven studies and projects include the Sacramento River Flood Control System Evaluation, the Cache Creek Settling Basin project, the Folsom Dam and Reservoir Reoperation Study, the American River Watershed Investigation, and the Yolo Bypass Study. The Corps, along with State and local interests, is also investigating the possibility of restoring wetlands within the Yolo Bypass. In addition, the USBR has an authorized project on the American River at the Auburn Dam site.

Sacramento River Flood Control System Evaluation. The purposes of this five-phase study are to (1) evaluate the integrity and level of flood protection provided by the existing Sacramento River Flood Control Project levees, (2) determine whether the levees currently function as designed, and (3) determine the extent of Federal interest in construction if reconstruction work is needed. The five phases are : Phase I - Sacramento Urban Area; Phase II - Marysville/Yuba City Area; Phase III - Mid-Valley Area; Phase IV - Lower Sacramento Area; and Phase V - Upper Sacramento Area.

The first two phases of the evaluation focused on the heavily populated Sacramento urban and Marysville/Yuba City areas. The final three phases evaluating areas in the middle, lower (Delta), and upper Sacramento valleys, respectively. The middle valley area includes portions of the Yolo and Sutter Bypasses and levees on the Feather and Bear Rivers not considered in the second phase, as well as project levees on Yankee Slough and Dry Creek. The lower valley includes project levees south of Sacramento and West Sacramento, as well as tributaries to the west side of Yolo Bypass from Fremont Weir to Putah Creek. The upper valley is comprised of the area from Knights Landing north to Red Bluff, including tributaries such as Elder and Butte Creeks.

The investigation for the first phase resulted in a report, "Sacramento River Flood Control System Evaluation, Initial Appraisal Report - Sacramento Urban Area," issued in May 1988. Based on this report, detailed designs were initiated in April 1989 for structural rehabilitation of approximately 32 of 110 miles of levee evaluated in the Sacramento area. Construction is now under way. Construction is expected to be completed by late 1993.

The investigation for Phase II resulted in a report, "Sacramento River Flood Control System Evaluation, Initial Appraisal Report - Marysville Yuba City Area", issued in January 1990. The results of the studies indicate that sections of federal levees along the Feather and Yuba Rivers and their

tributaries are susceptible to seepage problems and do not provide the "design" levels of flood protection. About 30 miles of remedial repairs are required to meet project design requirements.

The Phase III report, " Sacramento River Flood Control System Evaluation, Initial Appraisal Report - Mid-Valley Area," was issued in January 1991. The report focuses on the leveed portions of the sacramento and Feather Rivers, the Yolo and Sutter Bypasses and numerous tributary streams and smaller waterways. The total length of the levees included in Phase III is about 240 miles. The Corps has identified about 30 miles of levees which require repair. A programmatic EIS is being completed for Phases III through V.

Cache Creek Settling Basin Project. This project will raise the levees surrounding the existing Cache Creek Settling Basin at the entrance to the Yolo Bypass to reestablish the ability of the settling basins to trap sediment and thus substantially reduce sediment deposition in the Yolo Bypass. Construction began in late 1990.

Folsom Dam and Reservoir Reoperation. This study is assessing the costs, benefits, and other impacts resulting from the temporary modification of the flood control operation of Folsom Dam and Reservoir to provide greater flood protection for parts of the Sacramento area. The study is assuming that reoperation of Folsom will be required for about 10 years, the design document and EIS are scheduled to be completed by mid-1992. It is anticipated that within this time frame, existing flood control facilities will be improved and the construction of a new flood control facility completed, making continued reoperation unnecessary. The Corps, with the cooperation of the USBR, is completing environmental studies.

American River Watershed Investigation. A Feasibility Report/Environmental Impact Statement/Report (FR/EIS/EIR), defined flood problems in the American River Watershed, including the 55,000-acre Natomas area, and developed alternatives to resolve those problems. The investigation also considered water supply and recreational development needs in the watershed. The report's Selected Plan recommends construction of a 200-year, flood- control-only facility located above Auburn, with levees raising around Natomas and a detention basin in northeast Natomas.

According to the report, a significant flood threat would remain with any protection lower than 200 years. Studies indicate that 200-year (or greater) protection could be achieved only with a new flood detention capacity located upstream of Folsom Dam in the upper American River canyon. (This study assumes that the USBR Auburn Dam Project will not be constructed as currently authorized.)

Potential modifications to the Fremont Weir and Yolo Bypass, which were initially a part of the Sacramento Metropolitan Area Study, were transferred to the American River Watershed Investigation after a determination that they primarily benefitted the Natomas area. The Board, the non-Federal sponsor, concurred in the transfer since local entities, particularly the City and County of Sacramento, which would derive the most benefit from the modifications, were already cost sharing in the American River Watershed Investigation.

Yolo Bypass Reconnaissance Study. This study is evaluating the flood problems and potential solutions along the Yolo Bypass from the Fremont Weir south to Liberty Island in Yolo and Solano Counties. The focus is primarily on the west side of the Bypass, including the Colusa Basin Drain, Cache Creek, Putah Creek, and Willow Slough, and the Elkhorn area, which is located between the Sacramento River and the east levee of the Yolo Bypass, with the Fremont Weir on the north and the Sacramento Weir on the south (see Plate 2). The Elkhorn area was initially included in the Sacramento Metropolitan Area Study, but was transferred to the Yolo Bypass Study at the request of the local sponsor to analyze measures to provide increased flood protection for the Elkhorn area.

Yolo Basin Wetlands Project. This project was authorized by the Water Resources Development Act of 1986, Section 1135(b) to restore wetlands within the Yolo Basin area and contribute to a larger program currently being planned by an interagency group of Federal, State, and local agencies and organizations. Corps planning and engineering expertise is being used to create and restore wetlands on and adjacent to project lands. Proposed work includes physical improvements within and adjacent to the permanent and seasonal wetlands, riparian forest, and upland grassland habitat.

Proposed improvements include excavating permanent wetlands, modifying the existing irrigation system, constructing small dikes and weirs for seasonal wetland impoundments, and constructing maintenance roads, fences, and gates. The State and the City of Davis, who are the local sponsors, are contributing lands. The California Department of Fish and Game is sponsoring two parcels within the Yolo Bypass, and the City of Davis is sponsoring a parcel adjacent to the Willow Slough Bypass. When construction is completed, the Corps will monitor each site for a year and then turn the sites over to the local sponsors for long-term management.

Authorized Auburn Dam Project. The USBR's Auburn Dam was authorized in 1965 under Public Law 89-161 as part of the Auburn-Folsom South Unit. As authorized, the dam would be about 653 feet high and impound a reservoir of 2.3 million acre-feet. When operated with Folsom Reservoir, it would provide a high level of flood protection to the Sacramento area. Construction of the dam began in 1967 but was suspended in 1975 after the Oroville

earthquake, pending further seismic evaluation. Although the dam was determined to be seismically safe in 1980, construction was delayed until downstream flow issues were resolved. To date, no non-Federal project sponsor has been identified, and construction of the authorized project has not been resumed.

In 1987, the USBR released a report prepared for members of a State/Federal Auburn Dam Task Force, which analyzed costs associated with five alternative reservoir sizes at the damsite. The USBR is currently conducting a water supply needs study which will include the evaluation of a multi-purpose dam at the Auburn site.

SACRAMENTO RIVER BANK PROTECTION PROJECT

This project is a long-term program that allows the Corps to use erosion control and setback levees to maintain the integrity of the Sacramento River Flood Control Project. Erosion control includes various forms of bank protection, but primarily consists of placing rock riprap to protect the levees. Setback levees involve moving existing levees farther from the river. The project area encompasses the 980 miles of levees along the east and west banks of the Sacramento River from Collinsville to Chico Landing; tributaries such as Steamboat Slough; and along the Feather, Bear, Yuba, and American Rivers; Sutter and Yolo Bypass; and smaller tributary streams.

YUBA RIVER BASIN INVESTIGATION

The reconnaissance study was completed in March 1990. Of the proposed alternatives investigated in the reconnaissance study, levee raising along the Feather and Yuba Rivers to provide at least a 150-year level of flood protection was found to be feasible. Detailed feasibility-level studies were initiated in September 1991. A draft feasibility report and EIS are expected to be completed in late 1993. Levee raising, if authorized, would take place primarily on the landward side of the levees, affecting primarily agricultural and grassland habitats. Detailed environmental analysis and mitigation studies will be conducted for the EIS.

Environmental Setting and Natural Resources

Study Location. The study area is located in Yolo County near the City of Sacramento and includes the City of West Sacramento in the southeast portion of the Sacramento Valley (see Plate 1). The study area, begins just upstream of the Sacramento Weir and extends downstream to Freeport, is bounded on the north by the Sacramento Weir, on the east by the Sacramento River, on the west by the west levee of the Yolo bypass and on the south by Freeport. A more detailed discussion of environmental resources can be found in the EIS/EIR attached to this report.

Area Description. Components of the Sacramento River Flood Control Project, including levees along the Sacramento River, Sacramento Weir, and portions of Yolo and Sacramento Bypass channels, lie within the study area. The Yolo Bypass occupies about 40,000 acres, the Sacramento Bypass 400 acres, and the West Sacramento area 12,000 acres. Flows emptying into the Yolo Bypass include those from the Colusa Basin Drain, Cache Creek, Willow Slough, and Putah Creek. The study area also includes the Ship Channel and associated Port facilities. A private levee forms the southern boundary of the West Sacramento area.

The south Sacramento area, flanked by the Sacramento and American Rivers, was to be initially evaluated for additional flood protection by both the American River Watershed Investigation and the Sacramento Metropolitan Area Study. Development of alternative plans for the American River Watershed Investigation, however, indicated that alternatives which protected south Sacramento from American River flows also protected the area from Sacramento River flows.

Since both with- and without-project conditions in the study area assume implementation of the Selected Plan for the American River Watershed Investigation, further analysis of alternatives to protect the south Sacramento area as a separate flood plain was not needed and therefore the south Sacramento area was deleted from this study. The revised study area for the Sacramento Metropolitan Area Study is delineated on Plate 1 and is basically the urbanized area of West Sacramento.

Geology and Soils. The study area is geologically part of the Great Valley Geomorphic province of California, which was filled with erosion debris from the surrounding mountains. Most soils in the area are recent alluvial flood plain deposits, consisting of clay, silt, and sand. Each floodflow deposits fresh alluvium, particularly within the bypasses.

Since completion of the Fremont Weir in 1929, sediment has been deposited on both sides of the weir, upstream to the Sacramento River and Downstream for several thousand feet into the Yolo Bypass. During extremely high flows, the Sacramento River Flood Control Project conveys water from the Sacramento River over the Fremont Weir into the Yolo Bypass. Because of the relative capacities of the Sacramento River and Yolo Bypass, the majority of floodflows from Sutter Bypass cross the Sacramento River and enter the Yolo Bypass. By the early 1980's, sediment had built up higher than the sill elevation, which induced approximately 1 foot higher flood stages at the weir during the 1983 and 1986 floods. In 1986 and 1987, the State removed about two-thirds of the sediment in and around the weir and in 1991 completed the cleanout to an average of about 3 feet below the sill elevation.

Climate. The Sacramento area has a mediterranean climate characterized by hot, dry summers and mild, rainy winters. The major portion of the seasonal rainfall generally occurs from December through February. The seasons are so distinctly different that the period from May to October may be termed the dry season and November to April the wet season. Precipitation in the Sacramento Valley, which usually falls as rain, varies from an average of 16 to 20 inches on the valley floor to about 70 inches in the higher mountains.

Local meteorological conditions result from the topography of the valley. Winds are channelled by the mountain ranges surrounding the valley so prevailing winds in West Sacramento are from the south and west. Air flow passes through the Carquinez Straits, bringing cool southerly winds from the ocean in the summer and rainstorms in the winter.

Air Quality. The study area lies within the Sacramento Valley Air Basin, and pollutant sources are classified as urban. The U.S. Environmental Protection Agency (EPA) has designated the basin, including West Sacramento, as a "non-attainment" area. Principal constituents of concern include ozone, nitrous oxide, and carbon monoxide. The West Sacramento portion of Yolo County has an unclassified status for carbon monoxide, which means that there are insufficient monitoring data to determine attainment status.

Federal air quality standards for ozone are exceeded several times each year. Motor vehicle emissions, pesticide use, and non-highway mobile sources (boats, off-road vehicles and aircraft) contribute to the air pollution problem. (See EIS/EIR Chapter 7.)

Water Quality. Water quality of the Sacramento River is listed as impaired from the Sacramento Slough to Rio Vista. Water quality can be affected by upstream agricultural discharges and runoff, which are highly turbid and contain pesticides and herbicides, and by urban and industrial runoff.

Water quality in the Yolo Bypass is determined by the quality of water entering the bypass. Similarly the Sacramento Bypass receives its waters from the Sacramento River. Water in the Ship Channel near the Port has a higher level of total dissolved solids than the Sacramento River because insufficient water moves through the lock to flush that portion of the channel. (See EIS/EIR Chapter 6.)

Vegetation. Vegetation in the study area includes mixed riparian forest, riparian shrub/scrub, freshwater emergent wetland, open water, valley grassland, and willow scrub.

Mixed riparian forest and riparian scrub form narrow, linear bands adjacent to the Sacramento River, Tule Canal, and various toe drains adjacent to the waterside of the levees. Trees

include oaks, sycamores, willows, and cottonwoods; the understory is herbaceous, composed of grasses, blackberry, poison oak, and wild rose. Emergent marsh vegetation is found in areas of open water near the Sacramento Bypass.

The central part of the Yolo Bypass is farmed, and riparian vegetation is confined to canals and toe drains. Putah Creek empties into the Yolo Bypass on the west side; at the creek's terminus there are areas of riparian scrub and forest.

Agricultural, industrial, and residential land uses in West Sacramento limit riparian vegetation to drainage ditches and areas along the Sacramento River. The levee adjacent to the east side of the Ship Channel is sparsely vegetated with grasses and forbs. (See EIS/EIR Chapter 8.)

Fisheries. The Sacramento River provides important spawning and rearing habitat for an abundant and diverse variety of both anadromous and resident species of fish. Anadromous species include striped bass, steelhead trout, American shad, and chinook salmon. Resident species include catfish, black bass, largemouth bass, black crappie, warmouth, Sacramento squawfish, and Sacramento sucker.

When Sacramento River floodflows are diverted into the Yolo and Sacramento Bypasses at the weirs, fish species inhabiting the river also enter the bypasses. When flows recede, depressions within the bypasses form temporary pools, and fish that are not flushed out are stranded. Because of the intermittent nature of flows, the bypass areas do not support permanent fish populations. However, the canals and toe drains do provide year round habitat for warm water species such as carp and catfish.

The Ship Channel supports anadromous sport species such as the king salmon, striped bass, and steelhead. Resident species include the channel catfish, brown bullhead, and sunfish. (See EIS/EIR Chapter 9.)

Wildlife. Wildlife species are associated with the type of habitat available for food, cover, and nesting. Riparian forest, valley oak woodland, and freshwater marsh areas are highly productive wildlife areas, which support such species as the house finch, scrub jay, acorn woodpecker, egret, owl, red-tailed hawk, Swainson's hawk, Virginia opossum, gray fox, raccoon, western gray squirrel, and muskrat. During the winter months, migratory waterfowl and raptors use the Yolo Bypass for the purpose of foraging and nesting habitat.

The open grassland and riparian scrub areas are used by the California ground squirrel, California vole, California quail, and American goldfinch, which feed on seeds and vegetation. Vertebrate predators include the red-tailed hawk and striped skunk.

Agricultural fields provide foraging areas for the red-tailed hawk, Brewer's blackbird, and Swainson's hawk, which often nest in nearby riparian areas and use agricultural fields and annual grassland for feeding. (See EIS/EIR Chapter 10.)

Rare, Threatened and Endangered Species. One Federally threatened species, the valley elderberry longhorn beetle is found in the project area. No Federally listed plant species are known to exist in the study area. In addition, several Federal candidate species, the California Hibiscus, California tiger salamander, Sacramento Anthicid Beetle, Sacramento Valley tiger beetle and the tricolored blackbird may occur in the area.

The giant garter snake, a State listed threatened species and a Federal candidate species which has been proposed for listing as a Federal Endangered Species, may also occur in the study area. Swainson's hawk, a State-listed species, nests in large trees (usually in riparian areas) and forages in agricultural fields in the study area. (See EIS/EIR Chapter 11.)

Socioeconomic Conditions

The City of West Sacramento, has an existing population of about 29,000 and contains approximately 12,000 acres; the extent of existing development is shown on Plate 3. Incorporated in 1987, the City is projected to grow to about 30,270 by 1998, assuming a minimum 100-year level of flood protection has been achieved (see Appendix A, Economics).

Population growth could be accelerated if transportation access problems to the southern part of West Sacramento are solved. Several new bridges would be needed to adequately handle the projected traffic volumes associated with growth in the West Sacramento area. A few residences and businesses are located along the Sacramento River, but no residential, commercial or industrial development is allowed in the flood bypass areas.

Wholesale and retail trade, manufacturing, the professions, and agriculture provide employment opportunities. In addition, the State has designated West Sacramento as an Employment and Economic Incentive Area, which provides incentives, such as hiring and sales tax credits, for new and expanding businesses to create new employment opportunities for local residents.

Land use is largely agricultural, with some marina and residential development along the river. The State or private interest manage several areas as refuges or wildlife management areas. About 40 percent of the land in the City of West Sacramento is urbanized, with development divided equally between residential and non-residential uses. The City has the largest concentration of industrial development in Yolo County.

The Port is a major shipping installation for the Sacramento Valley and has special status as a foreign trade zone, which

allows deferred or lower import duties and encourages new firms to conduct business in the area. The area surrounding the Port is developing as an industrial district. The immediate vicinity has a significant amount of new facilities for small-scale industrial and research and development activities.

A number of regional and local roadways and railroads service the study area. Interstate 5 (I-5), Interstate 80 (I-80), and Business 80/U.S. Highway 50 provide regional highway access. The Southern and Union Pacific Railroads service industrial areas in West Sacramento. (See EIS/EIR Chapter 17.)

Cultural Resources

Data from the study area firmly establishes human presence for the last 10,000 years. This is evidenced by a sequence of various artifactual assemblages representing either different cultures or cultural adaptations to the region.

Anglo-Europeans first visited the study area in the late 1700s although Western culture did not begin to exert a strong and lasting influence on the region until the early part of the 19th century: initially as a result of exploration parties, later as a result of trading expeditions, and subsequently as a result of mining activity that led to substantial settlements.

An information search of cultural resources information on file at Information Centers of the California Archeological Inventory was completed in June 1990. One archeological site was identified in the project area; however, field reconnaissance and augering at the site produced no indications of cultural material. A field reconnaissance of all proposed construction sites yielded no new cultural resources sites. A historic structure, the Sacramento Weir, was determined to be eligible for the Register of Historic Places in 1977. (See EIS/EIR Chapter 12.)

Recreation

The Sacramento River supports a variety of recreational activities, including fishing, boating, water skiing, hiking, and picnicking. About 20 marinas in the study area provide facilities for boating and fishing. Sport fishing is probably the most popular recreational resource of the river. Also, strips of riparian vegetation along the riverbank provide good areas for naturalists and birdwatching.

Recreational resources within the City of West Sacramento include 12 park sites 4 mini-parks; 7 neighborhood parks, which provide recreational programs; and 1 community park, Bryte Park, which provides recreational facilities and programs to all of West Sacramento. The City plans to develop its park system in the future, and a number of new parks have been proposed in conjunction with major development proposals in the study area.

Other recreational facilities include a KOA Campground, the Riverbend golf course and country club, and the El Rancho Bowling Alley.

Hazardous and Toxic Waste Sites

Hazardous and toxic waste sites located in the study area could require special design or construction considerations for the proposed levee alternatives. To identify known sites in the study area, the Corps reviewed lists maintained by the EPA, the State of California, and Yolo County. Sites near the proposed work are listed in Table 2 and their locations shown on Plate 4.

The EPA maintains and updates the Federal "National Priorities List" for uncontrolled hazardous and toxic waste sites, as required by the Comprehensive Environmental Response, Compensation and Liability Act of 1980. The latest list was published in the Federal Register, April 1991, on pages 35502 through 35525. The State of California Office of Permit Assistance in the Office of Planning and Research maintains and updates the Hazardous Waste and/or Substance Sites List (Assembly Bill 3750 list). The State Water Resources Control Board, California Waste Management Board, and Department of Health Services contribute to this list. The Yolo County Health Services Agency maintains and updates the Hazardous Material Site and Underground Tank Files, which lists local hazardous and toxic waste sites. The literature review indicated that the majority of the listed sites involved minor tank leaks and were not located in areas of any proposed new levee work, environmental mitigation, or borrow sites.

The Santa Fe pipeline site, which could be within the project right-of-way, involves a spill of 84,000 gallons of gasoline. Part of the liquid was recovered shortly after the spill, and contaminated soils will be excavated and disposed of or treated. In any case, proposed levee work near the spill site is directed away from the site. Since no levee work is proposed in this area, the site should not affect the proposed project although its status should be monitored throughout advanced studies. In addition, the U.S. Air Force Global Communication Transmitter Station site, which involves a tank leak of diesel fuel and trichloroethane, is located just outside the State's flowage easement area but within the Yolo Bypass. A preliminary assessment indicates no offsite migration of chemicals. This site is not located within the proposed construction area.

The Corps recently developed agency policy in response to the Comprehensive Environmental Response, Compensation, and Liability Act, which holds certain categories of individuals strictly liable for all cleanup and response costs of any hazardous substance regulated under the Act. The policy states that the local sponsor will generally be responsible for ensuring cleanup and paying response costs of any hazardous waste sites located on a civil works project.

TABLE 2

HAZARDOUS AND TOXIC WASTE SITES

Plate Ref. No.	Site Name	Location	Problem	Listing Agency	In Construction Zone/ Right-of-way	Comments
1	Conway Farms	CR27 & CR103 NE corner	1,2-dichloropropane	Yolo1/	no	
2	Contech Const	CR32A	Zinc, hydrocarbons	Yolo	no	
3	Continental Heller	4521 W. Capital Avenue	Tank leak	Yolo, State2/	no	
4	Court Galvanizing	CR32A	Heavy metals	Yolo	no	
5	Frontier Fertilizer	CR32A	EDB, DBCP, 1,2-dichloropropane	Yolo	no	
6	Holt Facility	5200 Chiles Road	Tank leak	Yolo	no	
7	Ink Co.	1871 Enterprise	Ink and solvents	Yolo	no	
8	Sante Fe Pipelines	Yolo Bypass North and West of City	Gasoline Spill	Yolo	yes	Pipeline ruptured by telecommunications contractor, releasing 84,000 gal of reg-unleaded gas. Est 25,000 gal recovered as liquid by vacuum trucks. Soil contaminated will be excavated and disposed or treated. Groundwater at 2 ft appears impacted.
9	Unocal Chem	Channel Drive	Nitrates, Hydrocarbons	Yolo	no	
10	USAF Transmitter	CR36 and Mace Blvd	Tank leak	Yolo	yes	Leak found Feb. 1986. Tanks removed May 1988. Prelim assessment found diesel and TCE in soils and groundwater, but no off-site migration of chemicals.

1/ Yolo County Health Services Agency. Hazardous Material Site and Underground Tank Files, March 1990.

2/ State of California Office of Permit Assistance. Hazardous Waste and/or Substance Sites List, March 1990.

January 1991

If hazardous and toxic waste exists in the construction area, the Government will determine as soon as possible the extent and nature of the contaminated material prior to construction. If construction is underway, the Government and local sponsor will decide whether to continue or terminate construction or, if possible, redesign the project.

If the Government and local sponsor decide to proceed or continue with construction after considering any liability that may arise under the Comprehensive Environmental Response, Compensation, and Liability Act, the local sponsor will be responsible for any studies and cleanup and response costs. In addition, the local sponsor will operate, maintain, repair, replace, and rehabilitate the project in a manner so that liability will not arise under the Act.

A field reconnaissance and review of aerial photos of the project area will be conducted during advanced studies to determine if there are any unlisted hazardous and toxic waste sites in the project right-of-way. A preliminary property review has already been conducted as part of the real estate portion of the study. Results of the field reconnaissance and an updated literature survey have been formally coordinated with the non-Federal sponsor and the appropriate Federal, State, and local agencies. In addition, the Corps will develop a contingency plan identifying a responsible agency and outlining a course of action in the event hazardous and toxic waste sites are uncovered during construction. (See EIS/EIR Chapter 18.)

FUTURE CONDITIONS

Population in the study area is estimated to increase about 72 percent from 1990 to 2048. Plate 5 identifies existing development and estimates future development in West Sacramento to the year 2048, assuming that a minimum of 100-year flood protection is achieved and that infrastructure is expanded as development occurs. Anticipated flood plain development is shown in Table 3. A more detailed projection of future land use is included in Appendix A, Economics.

Major residential, commercial and industrial projects are planned for West Sacramento in areas along the river, near the Port, and in Southport. Projects include the Lighthouse Marina, and the proposed Raley's Landing, Port of Sacramento Industrial Park, Southport Industrial Park, and development proposed in the Newport Specific Plan. However, without a minimum flood protection level of 100 years, the estimated depth of flooding would preclude development.

Without 100-year protection, development in the flood plain will be severely restricted after November 1992, when new development will be limited to structures that can comply with the Federal Emergency Management Agency's flood plain management regulations. This restriction would apply to virtually all of West Sacramento.

Future conditions in the bypass areas are expected to remain essentially the same. During nonflooding times of the year, the bypasses will continue to be managed as wildlife areas or farmed.

TABLE 3
FUTURE GROWTH IN FLOOD PLAIN
IN ACRES

LAND USE	1992	1998	2008	2018	2028	2038	2048	TOTAL
Residential								
Redeveloped[1]	4.8	0	7.7	31.0	1.4	5.8	0	50.7
Vacant[2]	53.6	35.2	56.4	151.2	194.0	207.9	223.1	921.4
Commercial								
Redeveloped	0	0	0.2	1.0	0	0	0.1	1.3
Vacant	0	0	0	3.7	16.0	8.9	15.8	44.4
Industrial								
Redeveloped	0	0	0	0	0	0	0	0
Vacant	17.2	49.8	79.0	82.5	70.4	55.5	60.8	415.2
Public								
Redeveloped	0	0	0	0	0	0	0	0
Vacant	0	82.1	4.6	0	0	0	0	86.7
Toal Vacant and Ag. Lands	7687.2	7520.1	7380.1	7142.7	6862.3	6590.0	6290.3	6290.3

1/ Growth on lands already in urban use.
2/ Growth on lands currently vacant or in agricultural use.
3/ There are currently 7,758 vacant and agriculturalacres in the flood plain.

CHAPTER III

PROBLEMS AND OPPORTUNITIES FOR RESOLUTION

FLOOD PROBLEMS

Historical Flooding

As a result of climatic and geographical conditions, regular flooding occurred naturally in the Sacramento Valley. During winter and spring months, the capacity of the Sacramento River in the valley area was insufficient to carry the heavy flows caused by precipitation and snowmelt, and the river overflowed into the surrounding countryside. The six historic flood basins in the Sacramento Valley are shown in Plate 6.

Indian folklore and newspaper accounts mention at least nine major floods prior to 1890. Losses throughout the Sacramento Valley as a result of these floods were large, totaling at least $11 million for the floods of 1904, 1907, and 1909. Until floodwaters subsided, transportation, business, and farming came to a standstill. More recently, large floods occurred in 1955, 1964, 1969, 1970, 1982, and 1986, which was the flood of record. Table 4 shows the estimated peak flows of these floods, which eroded and weakened levee embankments in the study area and necessitated on-site emergency work to prevent levee failure.

TABLE 4
FLOWS OF HISTORIC FLOOD EVENTS AT THE LATITUDE OF SACRAMENTO[1]

Date of Flood Event	Flows (cfs)
Dec. 1955	400,000
Dec. 1964	475,000
Jan. 1969	230,000
Jan. 1970	340,000
Dec. 1982	250,000
Feb. 1986	600,000

1/ Latitude includes Yolo Bypass and Sacramento River flows downstream of mouth of American River.

February 1986 Flood of Record

The series of storms that struck California in February of 1986 resulted in the flood of record for many parts of northern and central California. Record floodflows in the American River, together with high flows in the Sacramento River, caused encroachment into the design freeboard of levees protecting the Sacramento area. (Freeboard is the difference between the high water mark and levee crown elevations.) The inside slope of a portion of the Garden Highway levee along the Sacramento River eroded as a result of seepage through the levee, and only emergency repairs prevented complete failure. Had the storms

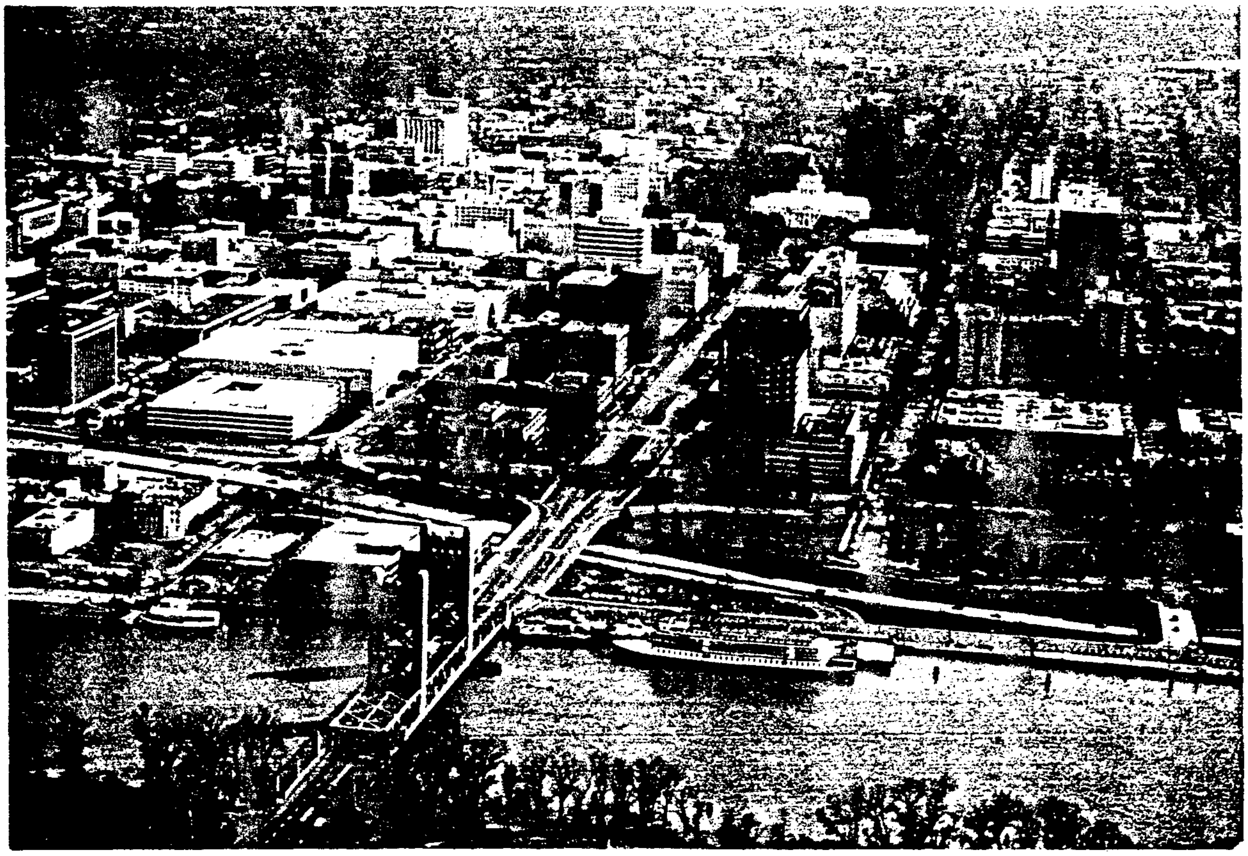
continued much longer, major sections of the levees would likely have failed, causing probable loss of life and billions of dollars in damage.

In the study area, riverflows and local tributary inflows almost exceeded the design levels of the flood control system. A photo of the Tower Bridge during the February 1986 flood demonstrates the high water level and its proximity to the metropolitan area of Sacramento (see Figure 1). Prior to the 1986 flood, West Sacramento was thought to have a 100-year level of flood protection. However, based on stage-frequency relationships (using unadjusted historic data), the frequency of the 1986 flood for the study area was estimated to be approximately 70 years for both the Yolo Bypass and the Sacramento River.

Stage-Frequency Relationships. Stage-frequency relationships and water surface profiles were developed to determine the current levels of flood protection throughout the study area and the benefits of any flood control alternatives to resolve the problems. Design flows and stages and peak flows and stages during the February 1986 flood at available gauging stations are compared in Table 5. Hydrologic and hydraulic numerical models were used to compute water-surface profiles for floods of various frequencies along the Sacramento River. A description of stage-frequency relationships is included in the Appendix C, Hydrology.

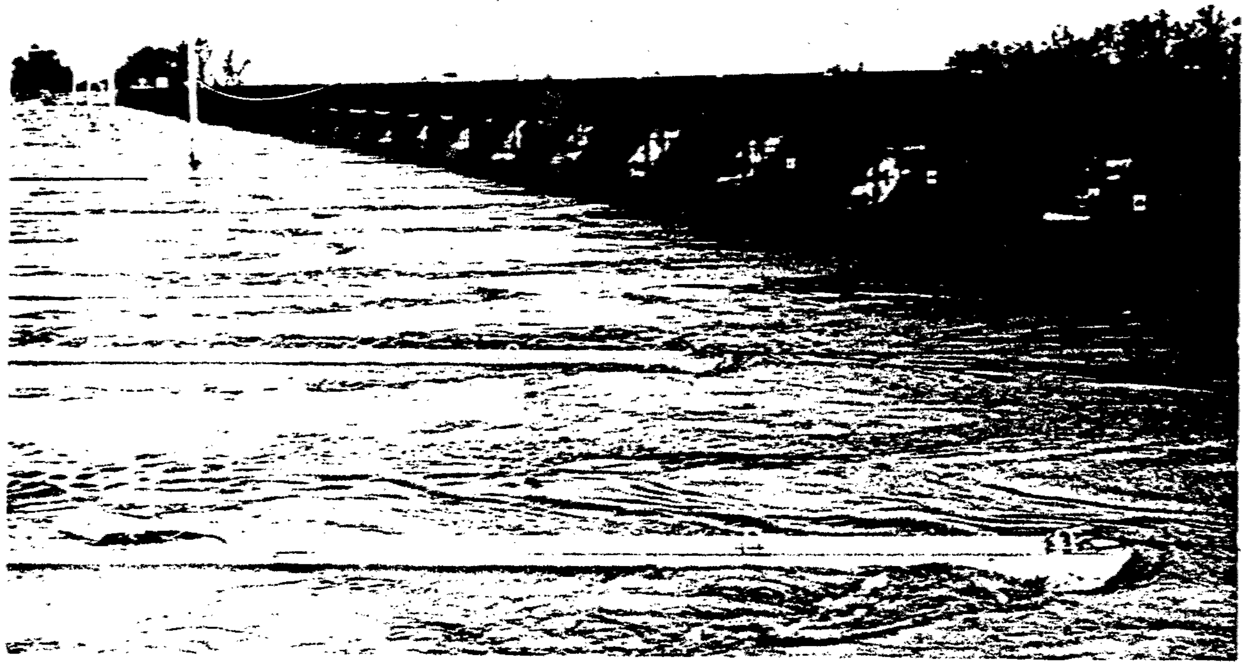
Consequences. The Sacramento River Flood Control Project weir and bypass system was built to direct reservoir releases and uncontrolled runoff around main population centers in the Sacramento Valley. However, this system was severely tested during the 1986 flood. As designed, the Sacramento Weir directs floodwaters from the Sacramento River into the Yolo Bypass, around the metropolitan areas of Sacramento and West Sacramento. During large floods, a portion of the American River flow moves upstream from the mouth of the American River along the Sacramento River channel to the Sacramento Weir, where it is diverted into the Yolo Bypass.

Table 5 shows that in 1986 the estimated peak flow over the Sacramento Weir exceeded the project design flow (see Figure 2). High flows in the river and wave action in the Yolo Bypass took their toll on the structural integrity of the levees, resulting in extensive damage (see Plate 7). Most of the damage to bypass levees was the result of erosion caused by waves observed at up to 6 feet. Emergency sandbagging was required to prevent overtopping and continued loss of embankment material from wave action.



SACRAMENTO RIVER AT TOWER BRIDGE DURING FEBRUARY 1986 FLOOD.

FIGURE 1



SACRAMENTO WEIR AND SACRAMENTO BYPASS NEAR PEAK OF FEBRUARY 1986 FLOOD.

FIGURE 2

TABLE 5

Comparison of Design Flows and Stages and Peak Flows and Stages during February 1986 Flood Event

Location	Design Flow (cfs)	February 1986 Peak Flow (cfs)	Design Stage (NGVD)[1]	February 1986 Peak Stage (NGVD)
Sacramento River at Verona	107,000	92,900	38.2	39.1
Sacramento River Fremont Weir Spill	343,000	341,000	37.8[2]	38.5[3]
Yolo Bypass near Woodland	377,000	374,000	31.3	31.5
Yolo Bypass near Lisbon	490,000	495,000 to 509,000 (estimated)	23.2	24.9
Sacramento River Sacramento Weir Spill	112,000	127,680	31.5[2]	30.6[3]
Sacramento River at Bryte			31.5	30.6
Sacramento River at I Street			31.1	30.6
Sacramento River at Freeport	110,000	117,000	25.4	25.1

1/ National Geodetic Vertical Datum.
2/ Design stage of Sacramento River opposite location of weir.
3/ Observed water surface elevation on Sacramento River 550 feet upstream of weir.

Although Sacramento River levees also had some wavewash damage, the majority of the damage was associated with seepage, boils and landside subsidence (see Figure 3), which often required emergency work by Federal, State and local agencies to minimize or prevent further damage during the flood. Plate 8 indicates some of the minimum freeboard observations for the 1986 flood, based on the corresponding water surface profiles. The freeboard remaining during the flood was determined by comparing surveyed high water mark information to surveyed levee crown elevations.

Wind velocities were not severe during the 1986 flood; however, severe wind velocities combined with wave action in any future floods with a magnitude similar to the flood of 1986 could compound problems in the study area. Additionally, a flood similar to 1986, but of longer duration, could increase the potential for structural failure and levee erosion because levee embankments would be subjected to pressure flows over longer periods.

Much of the critical damage to levee embankments was repaired under the Corps' Public Law 84-99 program. The Sacramento District received about 108 requests for assistance, resulting in 20 construction contracts totaling about $11 million to repair damaged levees within the Sacrament/San Joaquin drainage basin.

Emergency work under Public Law 84-99 on levees surrounding Reclamation Districts 1600, 827, and 785 (all within the Elkhorn area shown on Plate 1) totaled $400,000 in construction costs. In addition, substantial damages along the north Willow Slough Bypass and the west Yolo Bypass north of Willow Slough Bypass (Reclamation District 2035) resulted in about $170,000 of repair costs under the program.

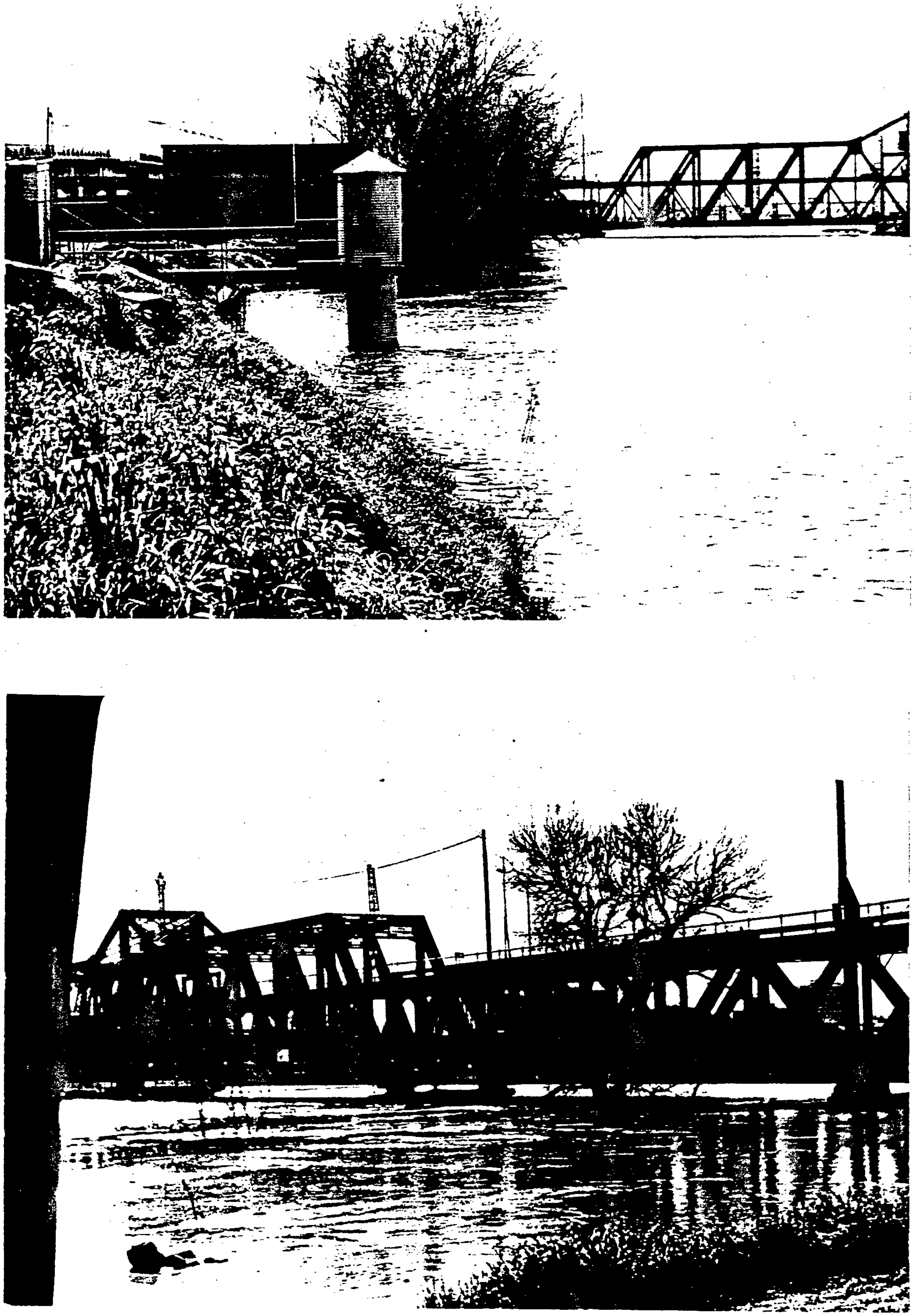
Repair costs for the Sacramento Weir totaled $180,000. The weir and the Sacramento Bypass suffered scour damage associated with high flows and velocities to the concrete apron just downstream of the weir (See Figure 4). Erosion and undercutting damaged the concrete pavement protecting the weir structure as well as the south levee embankment of the Sacramento Bypass. Seepage was observed along both the north and south levees of the bypass, while damage from wave erosion occurred where the Sacramento and Yolo Bypass levees intersect.

Upstream of West Sacramento on the Sacramento River, emergency activities to prevent further damage and possible failure along Garden Highway levees cost about $295,000.

About $30,000 was expended to lay rock over a damaged area along the east side of Yolo Bypass levees between the Southern Pacific Railroad track and I-80 in Reclamation District 900 (See Figure 5). The damage resulted from wave action, which wetted the levee crown and caused extensive levee erosion. During the storm, emergency sandbagging of the area by California Conservation Corps crews prevented overtopping of the levee embankments into West Sacramento. By the end of the following summer, an additional $50,000 had been spent on repair of damaged or low levees within the district. (This area was also damaged during flooding in 1983, necessitating emergency work levee repairs totaling over $500,000.)

Future Flood Threat

The flood of record demonstrated that the existing level of protection in the study are was insufficient and that the occurrence of a flood comparable to or larger than the 1986 flood could result in catastrophic damages and loss of life. Because of the threat of future flooding, the Corps initiated flood control studies for both the Sacramento and American Rivers to determine possible alternative solutions.

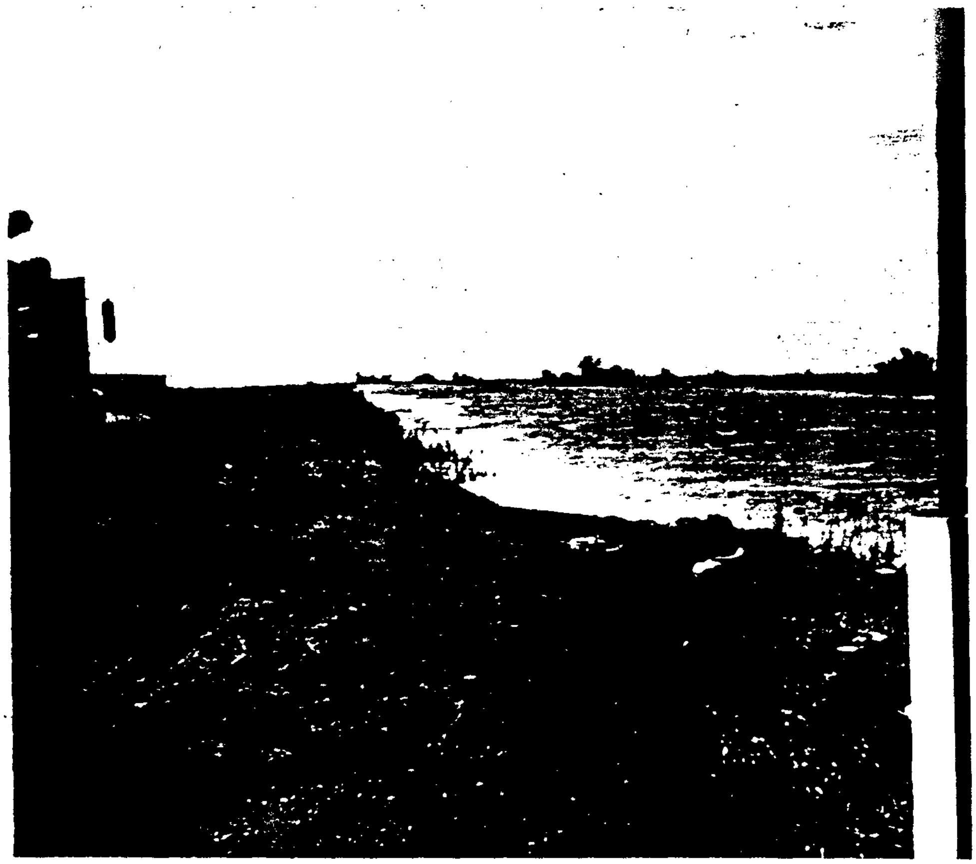


SACRAMENTO RIVER AT "I" STREET GAGING STATION AND BRIDGE DURING FEBRUARY 1986 FLOOD.

FIGURE 3

SACRAMENTO RIVER - WAVE EROSION OF WEST LEVEE EMBANKMENT NEAR FREEPORT (FEBRUARY 1986 FLOOD).

FIGURE 4



PLACEMENT OF ROCK ON WEST SIDE YOLO BYPASS LEVEE SOUTH OF I-80 (RD 900) DURING FEBRUARY 1986 FLOOD.

FIGURE 5

Study results indicated that even with a dam on the upper American River, levee raising in the study area would still be required to prevent flooding during times when the upper Sacramento and Feather Rivers were experiencing major flood. Historically, high flood stages in the study area have resulted primarily from various combinations of flows from the upper Sacramento, Feather, and American Rivers. Although a flood control dam on the American River, together with levee strengthening and raising in other parts of the study area, would increase West Sacramento's existing level of flood protection, caution should be expressed regarding the future flood threat. A flood control dam on the American River would not alleviate floodflows from the Yolo Bypass, which present the primary flood threat to the City of West Sacramento.

On the American River, additional flood control detention space could reduce the flood threat when the American River watershed experienced significant runoff. Reduction of flow in the American River would result in a reduction of peak flows on the Sacramento River downstream of the mouth of the American. For this flooding, upstream detention could alleviate some of the flood threat along the eastern border of West Sacramento and the western border of south Sacramento. However, for those floods in which the major runoff was from the upper Sacramento and Feather Rivers, a flood control dam on the American River may not significantly reduce the threat of future flooding from the Yolo bypass to the city of West Sacramento.

Land use changes and future development in the study area could also pose problems. If the minimum 100-year level of flood protection is provided to the study area, increased development will occur in accordance with the General Plan. However, such development, combined with only a minimum level of flood protection, could result in greater numbers of people being placed at risk.

In addition, implementation of projects that may increase levels of protection for upstream areas could impact the study the study area. Significant modifications to upstream levees which confine more floodwaters within existing or new flood control channels, could increase the volume of floodwater reaching the study area for floods greater than 100 years. Such projects consider potential downstream impacts and the possible need for downstream mitigation.

OPPORTUNITIES FOR RESOLUTION

Flood Threat

In the aftermath of the 1986 storm, flood frequencies in the Sacramento River Basin were reevaluated. The frequency and extent of major flooding in the study area were estimated on the basis of hydrologic information and data on levee and channel conditions. Recent studies have shown that large

floodflows on the Sacramento River may occur much more often than previously believed and that currently the urbanized area of West Sacramento has less than a 100-year level of flood protection. The existing flood control system in the Sacramento River is now estimated to provide significantly less than a 100-year level of protection.

As a result of the flood threat and in accordance with Public Law 87-874, the State and Corps initiated the Sacramento Metropolitan Area feasibility study to determine possible opportunities for resolving the flood control problems. Construction of a project authorized by Congress would require a non-Federal contribution of at least 25 percent of the project costs, in accordance with the cost-sharing provisions of the Water Resources Development Act of 1986 (Public Law 99-662). Flood control alternatives were formulated and potential measures evaluated, as discussed in Chapter 4, Plan Formulation.

Recreation

The proposed flood control facilities offer an opportunities for incorporating potential recreational uses. Recreation development could be accomplished by the Federal government in partnership with a local sponsor, usually a city or county parks and recreation department.

Existing recreational activities on the Sacramento River include fishing, boating, water skiing, hiking, and picnicking. Along both the Yolo and Sacramento Bypasses, recreational activities are limited to fishing for warm water resident fish. Although demand for recreational facilities is expected to increase in the future as local and regional populations increase, recreational opportunities in the study area are limited due to seasonal flooding of the bypasses and limited public access.

With project implementation, service roads on the crown of levees could be used as recreation trails serving bicyclists, equestrians, hikers, and runners. Appurtenant supporting facilities such as staging areas, parking lots, signage, landscaping, and gates could be included to enhance the recreational development. Another opportunity could be improved access to fishing areas, such as trails or parking areas.

Recreation costs are shared with the local sponsor, who is also responsible for operation and maintenance of the completed recreational facility. Recreation development is limited to project lands unless health and safety considerations warrant using additional land.

The City of West Sacramento has informally expressed interest in incorporating recreation trails along the levee

reaches proposed to be improved. The City of West Sacramento currently has only one bikeway, which runs from downtown Sacramento, through West Sacramento, to Davis via the Yolo Causeway.

The EIR for the West Sacramento General Plan (April 2, 1990) lists four General Plan Policy Response items addressing bicycle paths, which state that the City will (1) create and maintain a system of bike paths which encourages walking or bicycling as an alternative to driving, (2) cooperate with other jurisdictions to design and implement an area wide bikeway system that connects residential areas with recreation, shopping and employment areas, (3) attempt to establish bicycle parking facilities at all new major public facilities, business and employment sites, and shopping centers, and (4) include bicycle and pedestrian ways in all new bridge crossings.

The City of West Sacramento is currently preparing a recreation master plan which will show proposed routes for future bikepaths and other recreation features. Other local entities such as Yolo County are also planning for recreational development in the area and are potential local sponsors. In addition, the Fish and Wildlife Service has commented that there are substantial opportunities to improve recreational facilities in the project area incorporating fish and wildlife resources. Although recreational opportunities exist such features must be cost shared with a non-federal sponsor. A local sponsor has not been identified at this time. The local sponsor must be willing to cost share 50 percent of the recreational features.

CHAPTER IV

PLAN FORMULATION

In accordance with Federal Water Resources Council's Principles and Guidelines, plan formulation is the process of developing and evaluating alternative plans to meet the needs and desires of society, as expressed in specific planning objectives, and selecting the plan that best satisfies the objectives. During plan formulation for the Sacramento Metropolitan Area Study, the following procedures were used in formulating and selecting a plan to be recommended for implementation:

- Establish specific planning objectives;
- Define constraints and criteria for formulating an implementable plan;
- Identify the alternative that maximizes National Economic Development (NED) benefits; and
- Compare and evaluate the alternatives and select a plan to be recommended for implementation.

PLANNING OBJECTIVES

Planning objectives were established to serve as guidelines for formulating and evaluating plans to address the problems and realize the opportunities identified in the study area. These objectives were to (1) reduce potential flood damages along the Sacramento River and Yolo Bypass and in the urban areas of West Sacramento and (2) preserve the study area's environmental and cultural resources, and (3) develop the selected plan in accordance with the Federal objective of water and related land resource planning, including features that contribute to national economic development and are consistent with environmental statutes, Executive Orders, and other Federal planning requirements for protecting the Nation's environment.

FORMULATION AND EVALUATION CRITERIA

The following criteria relate to the problems and opportunities in the study area and provide the basis for objectively and consistently evaluating the alternatives.

Technical Criteria

- Plans will be consistent with local city and county General Plans and with the provisions of the National Flood Insurance Program.

- The selected plan will not (1) significantly impact preproject conditions for floods exceeding project design, without determining if compensation measures are required and (2) significantly aggravate preproject flood hazards for downstream developments without compensating for the effects being considered.

Economic Criteria

- To the extent possible, benefits will be expressed in comparable terms, and evaluation of alternatives based on the same price level, interest rate, and project life.

- Each alternative considered in detail will be justified in the sense that total benefits associated with the objectives are equal to or exceed total adverse effects associated with the objectives.

- Project benefits will be based on analysis of conditions with and without a project.

- The selected plan will be the NED plan, which maximizes economic benefits over project costs, unless there are significant reasons to select an alternative plan.

Environmental Criteria

- Plans will be formulated to preserve and enhance the quality of the natural environment and, to the extent practical, preserve and enhance significant resources, including fish and wildlife, vegetation, land, air, water, open space, and aesthetic values.

- Mitigation for unavoidable environmental impacts will be developed, including strategies to avoid impacts and replace resources, and should be based on an incremental analysis methodology.

- The relationship of the proposed action to land use plans will be considered; the environmental impacts of proposed actions evaluated; any unavoidable adverse environmental effects delineated; alternatives to such proposed action identified; the relationship between local short-term uses and the maintenance or enhancement of any long-term productivity determined; and any irreversible and irretrievable commitments of resources involved in project implementation identified.

- The evaluation and preservation of historical, archeological, and other cultural resources will be considered.

Social Criteria

- Safety, health, community cohesion, and social well-being will be considered, the improvement of leisure activities and public facilities evaluated, and the displacement of people minimized to the extent practicable.

- Project impacts on the income, employment, business and industrial activities, population distribution, and desirable community growth will be considered.

- General public acceptance of alternative plans will be determined through public meetings, field inspections, informal meetings, letters, and other public involvement procedures.

- Alternative plans should be workable within the constraints of present and potential governmental structure.

PLANNING CONSTRAINTS AND CRITERIA

Plan formulation constraints for this investigation include Congressional direction and current applicable laws, regulations, and policies affecting the study area. In addition, the Principles and Guidelines define specific criteria that are applicable to the development of alternatives and plan selection for all Federal water projects. These criteria are:

- Completeness, or the extent to which an alternative provides and accounts for the investments and actions necessary to ensure that planned effects are realized.

- Effectiveness, or the extent to which an alternative alleviates specified problems and achieves the specified objectives.

- Efficiency, or the extent to which an alternative plan is the most cost-effective means of alleviating specified problems and realizing opportunities, consistent with protecting the Nation's environment.

- Acceptability, or the workability of an alternative with respect to acceptance by the public and State and local entities and its compatibility with existing laws, regulations, and public policies.

PRELIMINARY FLOOD CONTROL MEASURES CONSIDERED

At the onset of the study, the Corps and local interests identified a variety of possible flood control measures, including modifying existing weirs and levees, constructing diversion and storage facilities, deepening or enlarging channels, and developing nonstructural alternatives. When the study was initiated, the study area included the developed areas along the Sacramento River and the Yolo Bypass from the Fremont Weir to an area just south of Freeport (see Plate 9). As a result, of study area modifications during preliminary investigations, alternatives focused primarily on the urban areas of West and south Sacramento. As noted in Chapter II, these modifications included the transfer of portions of the study area to other Corps investigations:

- The Elkhorn area was transferred to the Yolo Bypass Reconnaissance Study at the request of the local sponsor to allow sufficient time for the development of additional land use information. This study is scheduled for completion in March 1992. As a result the original study area was modified to include only the area from the Sacramento Bypass to the area just south of Freeport.

- Potential modifications to the Fremont Weir and Yolo Bypass, which primarily benefitted the Natomas area, were transferred to the American River Watershed Investigation since this investigation included this area.

Preliminary flood control measures were evaluated according to technical, economic, environmental, and local acceptability criteria and were either retained or eliminated from further consideration, as described in the following paragraphs. Of the measures considered, modification of the Sacramento Weir and raising portions of levees in the study area were retained for further study. As discussed in Chapter II, further evaluation of the Fremont Weir and Yolo Bypass near the weir was transferred to the American River Watershed Investigation.

Modify Existing Weirs

The modification of existing weirs to allow greater volumes of floodwater to flow into the bypass system is accomplished by physical alteration of the weirs or removal or reoperation of weir gates.

The Fremont and Sacramento Weirs could be lengthened or lowered to allow greater volumes of floodwater to pass from the Sacramento River into the Yolo or Sacramento Bypasses, respectively. In addition, the gates on the Sacramento Weir could be removed or reoperated to allow earlier entry of flows from the Sacramento River into the Sacramento Bypass. Preliminary studies of the Sacramento Weir indicated that removing the gates or lowering the weir crest appeared feasible.

Fremont Weir options include lengthening the weir in combination with widening the Yolo Bypass, or lowering the weir. Such improvements were evaluated to determine their ability to divert greater floodflows into the Yolo Bypass, thereby reducing flood stages in the Sacramento River. Options involving lengthening the weir examined an extension of up to 1,000 feet. The east levee of the Yolo Bypass would be setback in order to better align the inlet of the Yolo Bypass with the outlet of the Sutter Bypass. The length of the levee to be setback (in a landward direction) is approximately 20,000 linear feet when widening the bypass 1,000 feet. The weir extension would match the current design. The embankment material would be replaced with a concrete weir and riprap to match the current design. Lowering Fremont Weir would involve lowering the crest elevation and reshaping approximately 9,120 linear feet of concrete weir. To ensure proper functioning of the weir, additional sediment removal would be necessary to lower the land surface to an elevation equal to or less than the weir crest elevations. Approximately 400,000 and 600,000 cy of material would need to be removed and disposed of when lowering the weir by 0.5 and 1.0 foot, respectively. When hydraulic evaluations of these alternatives were made it was found that they would not effectively reduce stages in the Sacramento River. The ability of these measures to divert more floodflows into the Yolo Bypass are limited by backwater effects resulting from constrictions in the Yolo Bypass farther downstream.

Modify Existing Levees

Raising existing levees would allow greater volumes of floodwater to pass through the system without causing damage, thus increasing the level of flood protection to the study area. Preliminary studies indicated that this measure was feasible, and it was considered in the development of alternative plans.

Several levee modification alternatives were analyzed including the following:

Floodwalls. Levees can be raised by adding embankment material to the top and sides of the levee or by building floodwalls on top of the levee. If levee height increases are small, floodwalls may be more economical that additional embankment. A flood wall requires a footing which must be covered by soil to provide adequate stability. A visible five foot floodwall could have an additional two to three feet of wall beneath the ground with a ten foot wide footing. This requires the top three feet of the levee to be excavated to construct the wall. The placement of a floodwall may not leave enough crest width to properly maintain or inspect the levee which would require increasing the existing crest width which would cause widening of the levee base. Also, floodwalls would be more aesthetically objectionable than grass covered earth embankments. Finally, the construction of floodwalls are much more expensive that placing additional embankment. For all of

these reasons it was determined that raising existing levees was more economically viable than constructing floodwalls on top of levees.

Cutoff Walls. Cutoff walls are used to reduce or eliminate seepage through a levee. Seepage can create stability problems and cause a levee to fail. However, seepage is not a problem with the Yolo Bypass levees. The problem in the Yolo Bypass relates to insufficient levee heights. Since this alternative does not address the requirements for additional levee heights, cutoff walls were not retained for further analysis.

Cross Levees. During preliminary evaluations cross levees were analyzed to determine if this alternative could be used to protect only the urbanized areas of West Sacramento. However, there are no strategic locations in the vicinity of Southport in West Sacramento to construct cross levees which would protect only urbanized areas. Consequently cross levees were not considered a viable means of achieving increased flood protection for West Sacramento.

Removal of South Cross Levee. The removal of the south cross levee was also analyzed. The cross levee serves two main purposes: 1) if levee break occurs the north of the urbanized area of West Sacramento the cross levee prevents flood waters from flowing into the southern position of the study area (near Freeport) and 2) if levee failure occurs south of the City of West Sacramento (i.e. River Mile 50) the cross levee prevents water from entering the urbanized West Sacramento area. In addition, if a levee break occurs north of West Sacramento, and the cross levee were to be removed, there is such an extensive volume of water that flood inundation reduction would be minimal. Based on these factors removal of the cross levee was not considered feasible and therefore, not evaluated as a possible flood reduction alternative.

Diversion Facilities

Diversion facilities such as pumps and overflow weirs move floodwaters from one segment of a river or bypass system to another. In the study area, water could be diverted from the Sacramento River or Yolo Bypass directly into the Ship Channel, thereby lowering the peak water-surface elevation in the Sacramento River and/or Yolo Bypass in the area of the diversion. Based on hydrologic information diverting flows of 20,000 to 40,000 cfs from the Yolo Bypass produces minimal impact on flood stage reductions in the study area for major flood events. As a result, diversion from the Yolo Bypass side was deleted from further consideration.

Hydrologic modeling efforts did indicate that significant reductions in flood stages for major flood events (similar to the 1986 flood event or larger) could be achieved in the Sacramento

River downstream of the American River by diverting excess floodwater from the Sacramento River into the canal via the lock. The costs and impacts to existing developments associated with this diversion are significant. Major port facilities, such as docks, loading cranes, warehouses, etc., would have to be relocated and/or reconstructed because new levees would be required on both sides of the Ship Channel adjacent to the Port. During those periods when floodwaters were diverted into the Ship Channel, ship traffic would be impacted. In fact, ship movement would probably cease. In addition, changes in erosion and deposition in the channel would probably increase dredging costs significantly. Because of these costs and impacts, the Sacramento-Yolo Port District, who owns and operates the Port of Sacramento, did not support using the Ship Channel as a diversion channel for floodwaters. Because of the increased costs, potential problems and local opposition, the alternative was deleted from further consideration.

Storage Facilities

Storage facilities such as detention basins and reservoirs reduce the peak flow of a flood through storage and controlled downstream releases. Because of the existing flood control system and the topography of the Sacramento Valley, there are no upstream reservoir sites that would be economically feasible at this time.

Deepen or Enlarge Channels

Channel deepening or enlargement through dredging, removing flow constrictions, or setting back levees allows greater volumes of floodwater to pass through the system. Dredging the Sacramento River was considered, but was dropped from further consideration because of the uncertainties involved in determining the impact of dredging in the Sacramento River and in conducting future maintenance dredging. In addition, because of the potential for catastrophic flood damages and loss of life, a permanent solution was considered necessary.

Flow constrictions (embankment material on I-80 and the Southern Pacific Railroad) could be removed and replaced with permanent bridge structures. Preliminary studies indicated, however, that such work was infeasible because of the high cost of the high construction costs and the impacts of traffic disruptions to the interstate highway system.

Setback Levees. The feasibility of setting back levees along the west side of the Yolo Bypass in the vicinity of West Sacramento was analyzed. It was determined that this alternative does not effectively provide additional flood protection to the West Sacramento area. Setting back these levees would require relocation of at least 5 miles of levees south of Willow Slough Bypass. Also, hydraulic analysis indicates that the increased flood storage provided by the setback levees does not effectively increase the conveyance capacity of the Yolo Bypass. Hydraulic

constrictions at the terminus of the Yolo Bypass near the Delta, and at the SPRR and I-80 embankments, limit the ability to discharge additional floodwaters. Setback levees by themselves only provide additional storage area for backwaters. Minimal reductions in flood stages would occur from the setback levee plan.

Consequently, in order for setback levees to have any effect existing constrictions must also be removed. Removal of constrictions at the SPRR and I-80 embankments were examined during reconnaissance investigations. (Removing these constrictions would only reduce water levels 0.5 to 1.0 feet). Costs of accomplishing this range from $140 to $245 million. These costs do not include costs associated with setting back the west Yolo Bypass levee. The setback levee plan would require removal of existing levees, construction of a new levee in excess of 30 feet high, and purchase of additional flood easements on many acres within the added flood bypass area. Consequently, the costs of this alternative eliminated it from further evaluation.

Table 6, summarizes economic considerations for these measures, based on October 1988 price levels when the analysis was completed, and 8-5/8 percent interest rate, and a 50-year project life. The information in Table 6 was developed for the Sacramento Metropolitan Area Reconnaissance Report dated February 1989. The ER 1105-2-100 guidelines state that the period of analysis is the time required for implementation plus the lesser of (1) the period of time over which any alternative plan would have significant beneficial or adverse effects or (2) a period not to exceed 100 years. It was determined for the purposes of the Reconnaissance study that 50 years was a sufficient period of time to meet the criteria for project implementation and adverse impact analysis. Further comparisons of the hydrologic, environmental, and construction costs are in Appendix B, Comparison of Flood Control Measures.

Nonstructural Measures

Nonstructural measures reduce flood damages rather than control floodwaters and may include (1) physical actions such as relocating, elevating, flood proofing, acquiring flood easements, and constructing floodwalls or small levees or (2) regulations and policies such as flood plain zoning, flood warning systems, and preparedness and evacuation plans.

Several nonstructural measures were considered in the West Sacramento area but were found to be impractical because of the depth of flooding, which precluded such measures as constructing water-tight closures or elevating structures in the flood plain. Flood proofing structures would involve raising existing structures so that habitable portions are above the expected flood level. Flood proofing could also involve the construction of walls around individual homes or pockets of homes to hold back the floodwater. This latter alternative is not considered a viable

alternative for the West Sacramento area because the "walls" would in fact be the existing "levees" in most instances. For developed portions of West Sacramento, there are no viable areas to construct a "ring levee" system without extensive relocations. In this case, upgrading of the existing levee system is much less environmentally damaging and more cost effective.

Raising structures above the flood level is possible if the lower portion of the structure is used only for parking or storage. The lower portion is expected to flood and is designed to equalize hydrostatic flood forces on exterior walls by allowing entry and exit of floodwater. Flooding would result in damage to contents in the lower portion such as automobiles and contents; however, the habitable portion of the home and upper level contents would be spared. Estimates of costs to raise a typical slab-on-grade house 10 feet above grade, including all finish work, have been done. For a 1,296 square foot house, the estimated cost is $39,552, or $31/square foot of slab. In West Sacramento, there are about 6,250 single family residential structures. Therefore, the cost to raise these residential structures would be nearly $250 million. In addition to these costs, an additional 5,500 structures would have to be flood proofed in some manner. Consequently, the high costs eliminated this alternative from further consideration. In addition, local interests would likely not support this alternative.

Flood easements provide flood protection to future development by requiring that development to occur in other less flood prone areas. The largest majority of Sacramento Metropolitan project benefits are for protection to existing development which would not be protected through the purchase of easements, therefore, this alternative was not considered feasible.

The City of West Sacramento is presently participating in the National Flood Insurance Program, regulated by the Federal Emergency Management Agency. New Flood Insurance Rate Maps prepared in March 1990 include nearly all of the City within the 100-year flood plain with a zone designation of A-99, which indicates that a Federal flood protection project is under construction. The City has until November 1992 to prove to the Federal Emergency Management Agency that adequate progress has been made in the project to provide 100-year flood protection.

The City's flood emergency response plans and flood fight plans are described in the Yolo County Emergency plan, which establishes procedures to be followed in the event of a natural disaster. These emergency programs are adequate for the City, and modifications are not needed.

TABLE 6

ECONOMIC SUMMARY OF FLOOD CONTROL MEASURES 1/
(1988 Price Level, 8-5/8% discount Rate, 1995-2045 Project Life, $1,000)

Flood control Alternatives 2/	First Cost Construction	Environmental	Annual Cost 3/	Annual Benefit	B/C Ratio
Modify Fremont Weir and Yolo Bypass					
Remove material	650	100	130	2,000 4/	15.4+
Widen 500 feet	9,000	1,000	925	minimal	--
Widen 1,500 feet	13,400	1,000	1,305	2,000 4/	1.5+
Lower weir 0.5 feet	1,470	100	200	2,000 4/	10+
Lower weir 1.0 feet	2,035	100	250	2,000 4/	8+
Modify Sacramento Weir and Bypass					
Remove existing gates	85	--	10	minimal 5/	--
Widen 500 feet	7,200	60	645	minimal	--
Widen 1,500 feet	14,900	60	1,325	minimal	--
Lower weir 0.5 feet	1,500	--	130	minimal 5/	--
Lower weir 1.0 feet	1,750	--	160	minimal 5/	--
Divert Floodwaters into the Sacramento River Deep Water Ship Channel	Preliminary evaluations indicate costs significantly greater than benefits				
Modify Levees around West Sacramento					
100-year plan	3,800	100	350	6,500	18.5
200-year plan	6,700	150	610	9,000	15
Remove Flow Constrictions from Yolo Bypass I-80 and the SPRR	141,000	200	12,500	significantly less than annual cost	--

1/ All values estimated from reconnaissance level data and are preliminary in nature.
2/ Assumes levees are structurally stable under existing design conditions.
3/ Includes monitoring, maintenance and environmental costs.
4/ Estimate of annual benefits are in excess of $2 million and are primarily attributable to the Natomas area.
5/ Benefits attributable to an ungated overflow structure have not been evaluated in sufficient detail other than for flood damage reduction benefits. Benefits attributable to reduced risk (elimination of the manual operation), reduced maintenance and operation costs and reduced amounts of levee improvements associated with other flood control alternatives have not been quantified.

DEVELOPMENT OF ALTERNATIVE PLANS

The formulation and evaluation of alternative flood control plans were based on the most likely conditions expected to exist in the future with and without the project. The without-project condition is the expected condition if no action (no Federal participation in a flood control alternative) is taken. The with-project condition is the expected condition with the proposed project in place.

Period of Analysis

The period of analysis for this study was considered to be 100 years from 1998 to 2098 and did not include the time required for project implementation. Although the actual base year, or the time the project would actually be on line and operational, would depend on Congressional authorization and funding, for the purpose of economic analysis, the study assumed the base year to be 1998.

Without-Project Condition

The without-project condition is developed to serve as a baseline for estimating and evaluating the beneficial and adverse effects of a potential flood control project. Estimates of future conditions were based, in part, on assumptions concerning construction of the proposed American River flood control project and development in West Sacramento. Without-project conditions assume that:

- Portions of the levee embankments of the Sacramento River Flood Control Project are structurally stable at the existing design water surface elevation. Work being completed in phase I and II under the Corps' five-phase Sacramento River Flood Control System Evaluation is considered to be part of without-project conditions. In phase I construction is now underway and scheduled for completion in November 1992 bringing the levees up to recommended design standards. Phase II work includes stabilizing levees in the Marysville-Yuba City area. Since phase II work will ultimately provide increased protection to an urbanized area, with potentially significant flood damages, there is a very high likelihood that this work will be completed. Studies for phases III, IV, and V are currently underway and the Corps is in the process of preparing the required environmental documentation. Therefore, because of the uncertainty associated with phases III through V they are not assumed to be in place. Initial phase III studies recommend remedial repairs along the east levee of the Yolo Bypass, including raising existing levees in low areas. Preliminary results of the phase IV studies recommend levee raising along the Willow Slough Bypass in the lower Sacramento area.

• Although land within the Sacramento and Yolo Bypasses is privately owned, the State maintains flowage easements (occasional flooding) over much of the land as part of the Sacramento River Flood Control Project. On the west side of the Yolo Bypass, where flows are unrestricted by levees, flowage easements generally follow the design water surface elevation, which corresponds to about a 20-year flood. The non-Federal sponsor will acquire flowage easements for about 1,700 acres of agricultural land within the Bypass and below the design water surface elevation for which no flowage easements were acquired. The cost of these easements is estimated at about $1.5 million. The acquisition of flowage easements in this area by the non-Federal sponsor is considered a without-project condition.

• The seasonal flood control space at Folsom Dam and Reservoir would continue to be 400,000 acre-feet. Currently, Folsom Dam and Reservoir regulated design outflows are 115,000 cfs or less, which is the safe channel carrying capacity of the American River downstream of Folsom Dam.

• The authorized USBR Auburn Dam and Reservoir will not be constructed.

• The Selected Plan for the American River Watershed Investigation is in place. The plan consists of a 200-year, peak-flow, flood-control-only facility located near the town of Auburn on the North Fork of the American River, various levee and channel modifications around the Natomas area, and a detention basin in northeast Natomas near Pleasant Grove Canal. Although this plan would control flows on the American and Sacramento Rivers for all floods up to 200 years, it does not include features to prevent flooding from the Yolo Bypass.

• All flood control improvements approved and under construction by local agencies as of September 1991 will be in place. These improvements do not include emergency flood fighting efforts during major floods because of the uncertainty of the effectiveness of these efforts.

• Flood stages associated with a 100-year flood can occur in the study area without breach of levees or loss of control at major upstream dams and reservoirs on the Sacramento and Feather River systems. Greater than 200-year level of flooding is strongly influenced by levee breaching upstream of the study area. At the 400-year frequency, the stage-frequency curve in the study area essentially becomes flat because of the large storage volume behind upstream levee breaches. This curve would remain flat until an extremely rare event in which flood volumes exceeded storage behind the levees.

• Residential, commercial or industrial development upstream of the study area during the 100-year period of analysis will not be significant. Any development that may occur in the

Marysville and Yuba City areas will not significantly impact flood stages in the Sacramento metropolitan area since about 8,000 cfs of additional flow is required to change the flood stage for a major flood by 0.1 foot in the Yolo Bypass. Significant development would be needed to produce 8,000 cfs of additional flow into the Sacramento River Flood Control Project system. In addition, because of differences in timing, surface water runoff from areas in the study area will generally peak prior to flows coming from the upper Sacramento and Feather River systems. Specifically the increased duration of flow releases in excess of 115,000 with the implementation of the ARWI project will not significantly affect coincidental peaks. Development in West Sacramento will be minimal because most areas that can be developed will be mapped within the Federal Emergency Management Agency's 100-year flood plain.

With-Project Condition

The with-project condition involves implementation of one or more flood control alternatives, which would increase the level of flood protection for the Sacramento metropolitan area. Each alternative plan was compared to the without-project condition over the period of analysis.

The with-project condition assumes implementation of the 200-year Selected Plan for the American River Watershed Investigation. Although work done in the Sacramento Metropolitan study area would not significantly impact upstream conditions along the Sacramento or American Rivers, the proposed work in the American River study area would impact the amount of work needed in the Sacramento metropolitan area to provide the desired levels of flood protection. Also, the two selected plans are expected to be combined into a single, comprehensive plan during the design and construction phase. Therefore, it is important that both studies use compatible without- and with-project assumptions.

In addition, the south Sacramento area is hydraulically linked to the study areas of both investigations. It was determined that controlling flows on the American River prevented flooding of South Sacramento from both the American and Sacramento Rivers because of decreased flows at the confluence of the two rivers. Consequently, measures that protected south Sacramento were not analyzed further in the Sacramento Metropolitan Area Study.

Technical Studies

The results of technical studies carried out during the investigation were used to develop and evaluate alternatives and identify the selected plan. Detailed descriptions are included as the appendices to this report (see Appendices A, C, D, and E).

Hydrology and Hydraulics. The hydrologic and hydraulic analysis (1) determined the current level of flood protection provided by the Sacramento River Flood Control System to the study area and (2) analyzed the impacts of various flood control alternatives on the system (see Appendix C, Hydrology). Although the studies specifically addressed the Yolo and Sacramento Bypasses and the Sacramento River below the Sacramento Weir, the contribution of over 23,000 square miles of drainage in the basin above West Sacramento was also determined (see Appendix C, Hydrology, Chapter II, page 4, for description of drainage area).

Because of flow and stage complexities, two computer programs were used to model the study area. The HEC-1 Flood Hydrograph Package was used to compute all rainfall-runoff and to route flows in areas where backwater was not a factor. In areas with major backwater influence, negative head differences, and stage-caused weir flow, the Dynamic Wave Operational Model (DWOPER) computer program was used to route flows and determine the relationship between stage and flow. Both models were calibrated using the 1983 and 1986 floods. These floods were used because the upstream basins reflected present conditions with all flood control features in operation. Furthermore, the 1986 flood was used because (1) it was the largest flood of record at many locations, (2) numerous field observations existed, and (3) a large network of stream gaging stations was in place to measure the flows and elevations during the flood.

To develop the flow hydrographs required by DWOPER, flow-frequency curves for the American River at Fair Oaks and volume-frequency curves at the Sacramento and Feather River confluence were developed. Separate curves for the American River included unregulated conditions and existing (regulated) conditions. The volume-frequency curves for the Sacramento and Feather River confluence reflect today's conditions with all present flood control features in operation and no levee failures until design flows have been exceeded. These volume-frequency curves were used to develop the 100-, 200-, and 400-year flood hydrographs and stages at various sites in the Sacramento River Flood Control Project system.

The DWOPER model used the 100-, 200-, and 400-year hydrographs to determine maximum water-surface elevations for these frequencies in the Sacramento River and Yolo Bypass. These maximum water surface elevations were for selected locations from the Sacramento and Feather River confluence downstream to Lisbon on the Yolo Bypass and to Courtland on the Sacramento River. To determine the current levels of flood protection in the study area and the benefits of flood control alternatives, stage-frequency curves and water surface profiles were developed, based on a variety of levee failure assumptions and physical conditions in the study area. Because of the constraints of DWOPER, the study area was divided into three separate models: the Sacramento River, American River, and Yolo Bypass.

The Fremont Weir, an ungated structure just upstream of the study area, controls the spill of upstream Sacramento River and Sutter Bypass flows into the Yolo Bypass. In most model runs, existing operation of the Fremont Weir was assumed. After the 1986 flood, the State of California embarked on a project to clear sediment from behind the weir that had impeded its function. As of January 1991, two-thirds of that sediment had been removed, and this condition was used in many of the model runs. The State is in the process of removing the final third. Model runs were made to determine the effect, if any, on the design profiles. Results indicated that although removal of this sediment significantly affected lowering flood elevations in the Sacramento River near Verona, it did not significantly impact flows in the Yolo Bypass near West Sacramento.

During the study, results of examining the effects of removing the gates or removing the gates and lowering the weir indicated that removing the gates during peak flood stages did not significantly affect the Yolo Bypass flows or the actual duration of flows in the Sacramento and Yolo Bypasses. However, the combination of removing the gates and lowering the weir did have some beneficial effect on lowering flood stages along the Sacramento River, but increased flood stages in the Yolo Bypass since floodwaters would enter the bypass slightly earlier. Overflows from the Fremont Weir would already have reached and entered the Yolo Bypass, so the overall effect would be insignificant. Also, the lower weir could increase the duration of flows in the Sacramento and Yolo Bypasses. The State has expressed interest in removing the gates at the Sacramento Weir. Operation of these gates is expensive and labor intensive.

Flood Plains. To adequately model the existing flood threat to West Sacramento, estimate potential flood plains, and calculate flood reduction benefits of project alternatives, stage-frequency curves and water-surface profiles were developed, based on developed levee failure elevations and physical conditions both within and upstream of the study area.

The volume-frequency curves for the Sacramento and Feather River confluence upstream of the study area assumed no levee failure until design flows had been exceeded. Emergency flood fighting efforts were assumed to be ineffective because of the uncertainty of implementing such efforts during major floods. Levee failure elevations were developed for levees within the study area along the Yolo Bypass, and the Sacramento and American Rivers (see Appendix D, Engineering Basis of Design, Levee Failure Criteria). This breach elevation scenario was based on engineering studies, recommendations by different engineering disciplines, and historical flood elevations. Following the minimum freeboard allowances developed for breaching scenarios, levees on the American River system, Sacramento River and Yolo Bypass were failed sequentially as the criteria were exceeded (see Appendix C, Hydrology).

The critical reach of levee for West Sacramento is the Yolo Bypass east levee from Sacramento Bypass to the Ship Channel. Because of the distress exhibited by the Yolo Bypass levees during the 1986 flood and the difference (about 2.5 feet) between peak elevations and the top of levee in critical areas, the 1986 high water was adopted as the final breach elevation. Because of insufficient freeboard, levee failures are most likely to occur near the Southern Pacific Railroad track or south of I-80 near the Ship Channel. Upstream of West Sacramento, levee failures are likely to occur in the Elkhorn area from both the Sacramento River and the Yolo Bypass.

Flood plains were evaluated for floods of various frequencies, using overland routing of flow hydrographs and recognizing the effect of physical features and storage volumes. Based on flow hydrographs and rating curves for the Yolo Bypass, a levee failure would allow floodwaters to flow initially into the north area of West Sacramento and then into the Ship Channel, which, although large, could not carry the floodwaters. Water would then pond behind the cross levee near the south city limits (see Plate 1) and flood the entire south City area. Within 30 hours of levee failure on the Yolo Bypass, floodwaters from a 100-, 200-, or 400-year flood would overtop and fail the cross levee, contributing to widespread flooding in Reclamation Districts 307, 765, and 999.

Maximum flood elevation in the West Sacramento flood plain is dependent solely on the maximum ponding behind the cross levee near the southern border of West Sacramento. Consequently, the 100-, 200-, and 400-year flood plains were all found to have a maximum flood elevation of about 25 feet, the elevation of the cross levee. The average depths of flooding in the 100-, 200-, and 400-year flood plains are also essentially the same (15 to 16 feet) because of the following: 1) the flood volume for each event is sufficient to fill the west Sacramento area and 2) the volume would reach a stage that is controlled by the height of the cross levee, which is about 25 feet. (See Plate 10).

Basis of Design. The Basis of Design was used to develop initial designs and cost estimates for various levee raising options (see Appendix D). Design aspects included alignment, levee design, freeboard, flood gates, potential hydraulic mitigation, quantities, real estate, and operation and maintenance requirements. The impacts of sedimentation and interior drainage were also considered in the preliminary designs.

Levee topography was determined from recent surveys of levee profiles and levee cross sections. The Department of Water Resources provided profile survey data developed in 1989 for Putah Creek, Willow Slough Bypass, Sacramento River east bank, and Yolo Bypass east levee. The Corps developed cross section survey data for the Yolo Bypass west levee in 1989.

The proposed levee work would consist of raising the existing levees without altering the existing alignment or design of any levee section. These sections have performed adequately, and a stability analysis determined that the levees would be stable even after being raised (see Appendix E). When determining whether new levee fill would be on the landside or waterside, consideration was given to the quantity of fill being placed and to environmental impacts, utilities, relocations, and development.

Since design water-surface profiles were developed using hydrologic and hydraulic model studies calibrated for the 1986 flood of record, the design profiles were considered to be very reliable for the design flows. As a result, no additional freeboard above the minimum was considered to be necessary to account for uncertainties in design profile calculations.

Levees are designed so that the freeboard conveys the design flows with a high degree of safety through the area of protection and so that levee failure would occur in an area or in a manner causing the least amount of damage or loss of life. The freeboard adopted for various levee reaches was 3 feet for the Sacramento River west levee; 6 feet for the Sacramento Bypass south levee; 6 feet for the Yolo Bypass east levee from the Sacramento Bypass to the Ship Channel; and 4 feet for the Yolo Bypass east levee from the Ship Channel downstream.

The additional 3 feet over normal freeboard for the bypasses was provided for wave runup. Because of the width of the Yolo Bypass, substantial waves can be generated by winds during floods. The additional freeboard would prevent these waves from overtopping the levees and causing a wave erosion failure. The 6 feet was reduced to 4 feet at the Ship Channel because of the levee cross sections in this reach. The levee that divides the Yolo Bypass and the Ship Channel has a 5 to 1 waterside slope which reduces the wave runup. Also, the levees are wider and have high berms behind them because of dredged disposal material from the Ship Channel. These more substantial levees are not as susceptible to wavewash erosion as other levees along the Yolo Bypass. For these reasons, a reduction to 4 feet of freeboard was considered appropriate for these levee reaches.

Two major transportation routes cross the project levees in the proposed construction area: a Southern Pacific Railroad line and I-80. The installation of a flood gate structure and monitoring system would be necessary at the railroad crossing. The existing 4 feet of freeboard is adequate at the I-80 crossing except for occasional overtopping because of waves; however, this overtopping would not damage the highway structure. Where the modified levee abuts I-80, riprap or concrete would serve to prevent erosion.

Hydraulic impacts associated with the levee-raising alternatives were analyzed in terms of changes in existing depth, duration, and frequency of flooding for adjacent and downstream

areas. If impacts are determined to be significant, hydraulic mitigation features, such as raising low areas of impacted levees, would be included in alternative plans.

Detailed quantities and costs developed for three basic designs, which encompassed all the alternatives, were used as the basis for developing all other designs.

An analysis of sedimentation and deposition in the Yolo Bypass indicated that under existing conditions (no improvements at the Cache Creek settling basin), Sacramento River overflow and Cache Creek flows deposit about 466,000 cubic yards of sediment annually. However, the 6 feet of freeboard used for the Yolo Bypass design is considered adequate to accommodate any changes in design flood stages caused by future sedimentation (see Appendix D for a detailed discussion of historic sedimentation).

The City of West Sacramento has an interior drainage system for the existing levees, as well as a plan to handle future interior drainage. Raising the levees would not alter the operation of the existing system or the plan for future flows.

Economic Analysis. An economic analysis was performed to calculate benefits attributable to a proposed project and compute future annual flood damages for with- and without-project conditions (see Appendix A, Economics). The analysis was based on a 100-year project life (1998-2098), October 1991 price levels, and an 8-3/4 percent interest rate. Excluding lands, roads, utilities, and bridges, total damageable property in the flood plain was valued at about $1.2 billion (October 1991 price levels). Average annual equivalent damages, under without project conditions, were estimated at about $10 million (October 1991 price levels). Probable average annual equivalent damages were estimated for the present year and the year in which growth would no longer continue to occur (1992). The latter damage figure (1992) has been held constant to the year 2098.

Property in the flood plain, which includes residential, commercial, industrial, public, and farm buildings, was inventoried through field surveys, aerial photography, or other data, and its value established. Depreciation was included in the valuing method. The main type of flood damage considered was physical damage caused by inundation, including impacts to, or loss of, buildings, lots, yards, roads, bridges and utilities. Agricultural damages were impacts to farm buildings and crops. Additional damages included emergency costs for evacuation, flood fighting, and disaster relief. Damages that could not be assigned a monetary value, such as loss of life, were not included in the damage analysis.

Damages were determined using the value of property, depth of flooding, and depth versus percent damage relationship. The relationships used in this analysis were based on the 1988 Federal Emergency Management Agency curves and curves from a Tennessee

Valley Authority study prepared for the Department of Housing and Urban Development in December 1969.

Potential benefits were identified and calculated after development of alternative plans. These benefits include inundation reduction benefits, location benefits, employment benefits, intensification benefits, flood insurance program benefits and savings in flood proofing costs.

PRELIMINARY ALTERNATIVES

Preliminary alternatives included modification of Sacramento Weir and Bypass and modification of levees around West Sacramento. Within the weir and bypass alternative, several options were developed to satisfy the planning objectives.

Modify Sacramento Weir and Bypass

To divert additional floodwaters into the Yolo Bypass, two options to modify the Sacramento Weir and/or its operation were considered. The Sacramento Weir consists of 48 manually operated bays or gates that are opened individually to adjust the flow passing over the weir. Each bay consist of 36, 3-by-12-inch wooden planks about 6 feet long. The effective overflow weir crest elevation is 21.5 feet. During any construction on the weir, traffic from Highway 16 and the Union Pacific Railroad would be rerouted or diverted.

Option 1. Remove the existing gate structures and form a smooth concrete surface along the weir with a crest elevation of 20.4 feet. The length of weir to be modified is approximately 1,824 feet.

Option 2. Lower the weir crest by either 0.5 to 1.0 foot while retaining the same gate configuration by extending the boards to their original length.

Detailed hydrologic analysis indicated that the flood hazard for West Sacramento is associated more with higher flows in the Yolo Bypass than with higher flows in the Sacramento River. Therefore, removing the gates or lowering the crest of the Sacramento Weir to decrease downstream flows in the Sacramento River would actually increase the flood threat in the study area by increasing flows in the Yolo Bypass. This option was therefore eliminated.

Removal of the gates (Option 1) would not impact peak flood stages in either the Sacramento River or the Yolo Bypass, but would realize a significant savings in the State's annual operation and maintenance costs without significantly altering the hydraulic functioning of the flood control plan. This option was eliminated from further consideration and placed under operation and maintenance authorities.

Modify Levees Around West Sacramento.

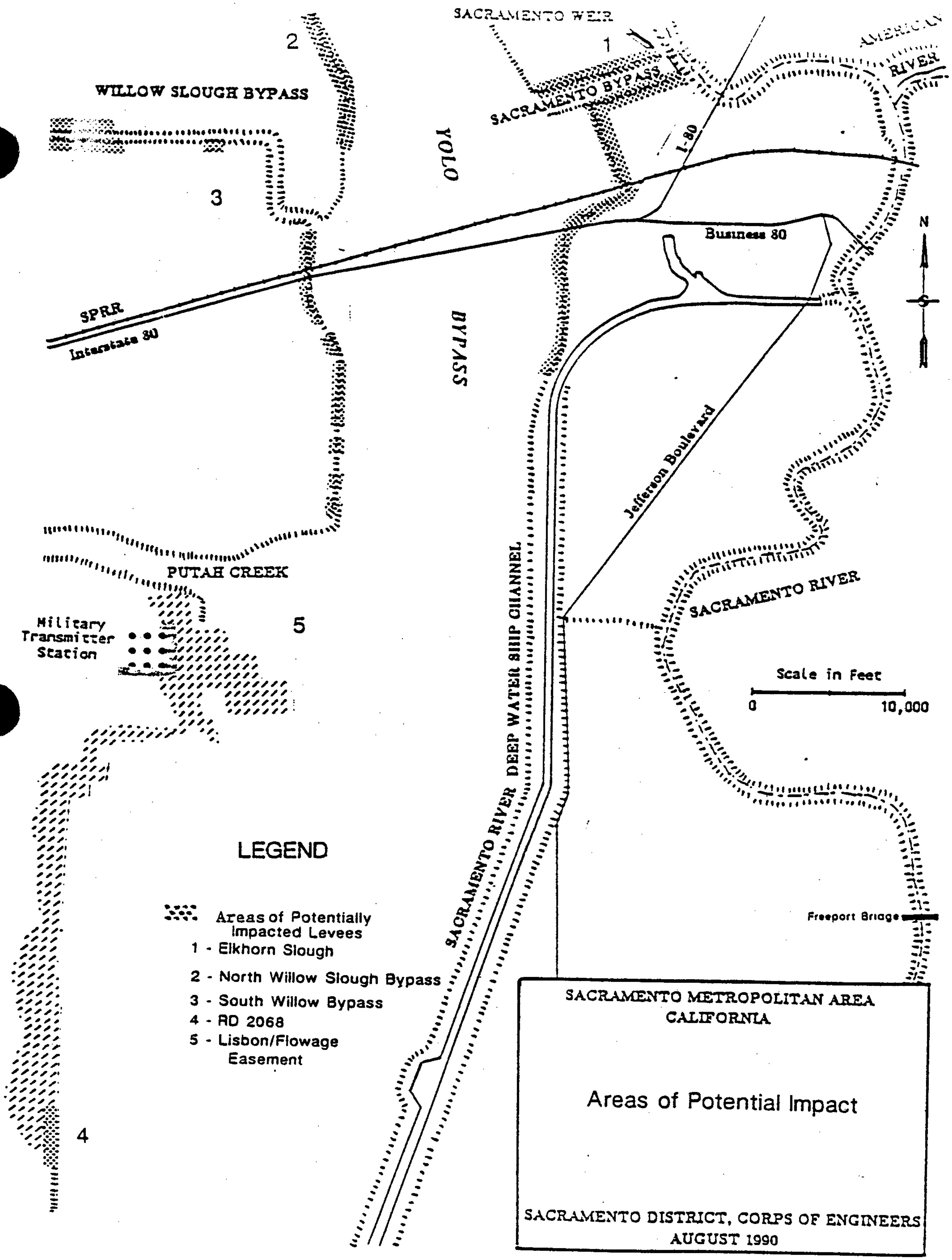
This alternative would raise portions of the levees around the City of West Sacramento to increase the level of flood protection to 100, 200, or 400 years. Approximately 30,600 linear feet of levee would need to be raised for each level of protection. Design levee crown elevations were based on 100-, 200-, and 400-year water-surface profiles and design freeboard criteria. This levee raising could potentially impact adjacent and downstream areas by reducing hydraulic conveyance and flood storage. These impacts could result in slight increases in water surface elevations, duration of flooding, and/or frequency of flooding.

The five leveed areas of potential impact included (1) the Elkhorn Slough area, which extends from the Fremont Weir in the north to the Sacramento Bypass in the south, (2) North Willow Slough, located south of Willow Slough and north of South Fork Putah Creek, (3) South Willow Slough Bypass, specifically the area west of the Yolo Bypass levee and north of the Southern Pacific Railroad tracks, (4) Reclamation District 2068, located in south Yolo Bypass, and (5) the Lisbon area, which extends just south of Putah Creek to an area about 4 miles south of Freeport. The locations of these potentially impacted levees are shown in Figure 6.

Raising the levees around West Sacramento to provide project design levels of flood protection would reduce the probability of levee failure and overtopping in this area. This reduction impacts adjacent flood features from the possible loss of flood storage in West Sacramento. Floodway capacity and levee freeboard for areas, primarily along the west side of the Yolo Bypass, could be affected. From the area just north of Willow Slough Bypass south to Putah Creek, the maximum increases to the existing flood stages were computed at 0.5, 0.9, and 0.9 foot for the 100-, 200-, and 400-year floods, respectively.

Further downstream in the area south of Putah Creek hydraulic studies indicated impacts of 0.2, 0.5, and 0.5 foot for the 100, 200 and 400 year floods respectively. Flowage easements define the existing project boundaries from just south of Putah Creek for approximately 8 miles until project levees begin again at the intersection of King Road and Road 104 in Reclamation District 2068. In Reclamation District 2068 hydraulic studies indicated impacts to the existing water surface elevations of 0.1, 1.0 and 1.1 feet for the 100, 200, and 400 year floods respectively under with-project conditions.

An analysis was performed to determine the significance of the hydraulic impacts of the 100-, 200-, and 400-year floods by comparing the depth, duration, and frequency of flooding in the five impacted areas under with- and without-project conditions.



SACRAMENTO WEIR
1
2
WILLOW SLOUGH BYPASS
AMERICAN RIVER
SACRAMENTO BYPASS
I-80
YOLO
3
Business 80
N
SPRR
Interstate 80
BYPASS
Jefferson Boulevard
DEEP WATER SHIP CHANNEL
PUTAH CREEK
SACRAMENTO RIVER
Military Transmitter Station
5
Scale in Feet
0
10,000
SACRAMENTO RIVER
LEGEND
Areas of Potentially Impacted Levees
1 - Elkhorn Slough
2 - North Willow Slough Bypass
3 - South Willow Bypass
4 - RD 2068
5 - Lisbon/Flowage Easement
Freeport Bridge
4
SACRAMENTO METROPOLITAN AREA
CALIFORNIA
Areas of Potential Impact
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
AUGUST 1990

Figure 6

For this analysis, levee failure was assumed to occur when the water surface encroached halfway into the design freeboard, or the 1986 profile, whichever was higher.

The DWOPER computer program was used to route flows and determine maximum water-surface elevation for these frequencies at the five areas of impact. The difference in the depth, duration, and frequency of flooding for each area under the 400-year flood is described below:

The Elkhorn Slough area. This area is susceptible to flooding from the Yolo Bypass on the west and the Sacramento River on the east. The existing design level of flood protection for the Elkhorn Slough area is about 20 years with 6 feet of freeboard. During a 400-year flood failure would occur, and flood the area to about 14 feet. In the Elkhorn Slough area the difference in water-surface elevation between with- and without-project conditions during the 400-year flood is 0.8 foot. With the levee raising alternative the design level of protection for the Elkhorn Slough area would decrease from 20 to 15 years.

North Willow Slough Bypass. The difference in average depth of flooding between with- and with-project conditions under a 400-year flood is about 0.6 foot for the North Willow Slough. The existing design level of protection with 6 feet of freeboard is 30 years, which would decrease slightly to 25 years with the levee raising alternatives. Under with-project conditions, the duration of flooding would increase about 0.5 day. Existing flooding of the area may result from levee failure of either the Willow Slough Bypass or Yolo Bypass levees and/or backwater effects along Willow Slough Bypass from the Yolo Bypass. The estimated duration of flooding in the North Willow Slough area during a 400-year flood would increase from about 4 days to 5 days.

South Willow Slough Bypass. The Willow Slough Bypass area would flood from either a failure of the Willow Slough Bypass and Yolo Bypass levees and/or backwater effects from the Yolo Bypass. The existing design level of flood protection with 6 feet of freeboard is about a 30-year level. The results of the hydraulic impact analysis indicate that a slight increase in depth and duration of flooding would occur with the levee raising alternatives. The estimated average depth of flooding would increase about 0.9 foot during a 400-year flood. With levee raising alternatives, the design level of protection would change from the existing 30-year to 25-year and the flood duration would increase by 0.5 day.

Reclamation District 2068. The District now experiences flooding from Cache Slough located to the south. The difference in depth of flooding between the with- and without-project condition for the 400-year flood is 1.1 feet. The design level of protection for the area is 35 years, which does

not change under the with- or without-project conditions since this area is flooded primarily by Cache Slough drainage. The duration of flooding may increase up to a day during a 400-year flood.

Lisbon Area. The Lisbon area, which is adjacent to the Yolo Bypass, will flood with or without the proposed project. Hydraulic studies indicate that existing levees provide 35-year flood protection and that levee failure could occur at or above that flood. Increase in the depth of flooding because of construction of levee alternatives is about 0.4 foot. Implementation of the levee raising alternatives would not impact the existing design protection; however, duration of flooding may increase up to a day during a 400-year flood.

Economic Evaluation of Hydraulic Impacts. An economic evaluation, using average annual benefits and costs, was completed to determine the economic feasibility of hydraulic mitigation. To mitigate for hydraulic impacts, low areas of the impacted levees would be raised by the impacted amounts for the three levee alternatives. The north levee of the Sacramento Bypass would be raised to the same design levels used for the south side. For the flowage easement area located just south of Putah Creek to the north end of the RD 2068 levee, additional easements would be acquired for each levee alternative amounting to about 3,370, 3,530, and 3,690 acres for the 100, 200, and 400 year plan. In addition to avoid relocating the Military Transmitter Station located just south of Putah Creek, a small ring levee was proposed to accommodate all design levels. Additionally, as a final hydraulic mitigation feature, approximately 5,000 feet of Road 104 would be raised about 1.1 feet for all design levels, just north of where the west levee of the Yolo Bypass resumes in Reclamation District 2068. Figure 6 on page 54 depicts the project features, including hydraulic mitigation, for the 100-, 200-, and 400-year plans.

A comparison of the added damages due to the increases in flood stages from the levee raising alternatives and the estimated costs of the mitigation features indicated that they were not economically justified. Benefit-to-cost ratios ranging from .04 to .20. These low ratios resulted from existing land use (primarily agriculture with few structures present) and small increases in flood stages.

In addition, a determination was made as to whether any hydraulic impacts associated with the levee raising plan would result in a "taking" within the meaning of the 5th Amendment of the United States Constitution, thus necessitating payment of just compensation and acquisition of the affected property. Generally, a "taking" occurs when there is either a physical appropriation of private property or a substantial interference with the property which destroys or lessens its value.

Results of the hydraulic impact analysis indicated that implementation of the levee raising alternatives would impact adjacent and downstream areas. The water-surface elevation and frequency of failure for each of these areas would increase slightly if the levee raising alternatives were constructed. In each of the impacted areas, flood waters would remain on the property approximately 0.5 to 1.0 day longer under with-project conditions. The predominant land use as stated earlier in each of the impacted areas is agriculture.

With respect to hydraulic impacts on depth, duration, and frequency of flooding to the downstream levees, there is no certainty that failure will in fact occur or where it may happen. This is supported by the fact that an 70-year flood occurred in 1986, and the levees in question did not fail. In addition, flooding in the impacted areas could occur from sources other than the Sacramento River or Yolo Bypass, specifically from the west side tributaries. Considering that the property in the subject areas is zoned for agricultural use, there is no indication that either the value or use of the property is significantly affected by the projects induced flooding. Based on the impact analysis, it was determined that hydraulic mitigation measures were not needed as part of the design features of the levee raising alternatives. (See Appendix D for details).

DESCRIPTION OF FINAL ALTERNATIVE PLANS

No Action

Under no action, the Federal Government would not participate in flood control alternatives, and the existing level of protection for West Sacramento would remain at about 70 years. The flood stage level for the 70-year flood would encroach into the levee freeboard in West Sacramento by about 3 feet.

100-Year Plan

This alternative consists of raising portions of the levees around the City of West Sacramento to increase the level of flood protection to 100 years. Design levee crown elevations were based on the 100-year water surface profile and design freeboard criteria. The levees would be raised a maximum height of 4.2 feet along 5,800 linear feet of the south levee of the Sacramento Bypass and 4.7 feet along 24,800 linear feet of the Yolo Bypass east levee. Levee raising would be landward for the south side of the Sacramento Bypass and the Yolo Bypass south of the Southern Pacific Railroad to the Ship Channel and waterward on the Yolo Bypass between the Sacramento Bypass and railroad.

200-Year Plan

This alternative consists of raising portions of the levees around the City of West Sacramento to increase the level of flood protection to 200 years. Design levee crown elevations were based on the 200-year water surface profile and design freeboard criteria. The levees would be raised a maximum height of 4.8 feet along 5,800 linear feet of the south levee of the Sacramento Bypass and 5.3 feet along 24,800 linear feet of the Yolo Bypass east levee. Levee raising would be landward for the south side of the Sacramento Bypass and the Yolo Bypass south of the Southern Pacific Railroad to the Ship Channel and waterward of the Yolo Bypass between the Sacramento Bypass and railroad.

400-Year Plan

This alternative consists of raising portions of the levees around the City of West Sacramento to increase the level of flood protection to 400 years. Design levee crown elevations were based on the 400-year water surface profile and design freeboard criteria. The levees would be raised a maximum height of 5.0 feet along 5,800 linear feet of the south levee of the Sacramento Bypass and 5.5 feet along 24,800 linear feet of the Yolo Bypass east levee for the 400-year level of protection. Levee raising would be landward for the south side of the Sacramento Bypass and the Yolo Bypass south of the Southern Pacific Railroad to the Ship Channel. Levee raising would be waterward on the Yolo Bypass between the Sacramento Bypass and Southern Pacific Railroad.

Environmental Mitigation Features of the Alternative Plans

Mitigation for unavoidable impacts resulting from the implementation of the 100, 200 or 400-year plans was developed, including strategies to avoid impacts. The mitigation requirement includes the creation of a combination of wetlands and uplands habitat types. Several sites were considered for environmental mitigation. All proposed mitigation is located within the project area; potential sites are shown on Plates 12, 12A, and 12B. The sites were evaluated using the Habitat Evaluation Process, and the most cost effective sites ultimately evaluated. The alternative mitigation sites are described below:

Site A. This approximately 5 acre site, located on the landside of the Sacramento River west levee in the southern portion o West Sacramento, extends just north and south of an area known as "The Bee Lakes" in West Sacramento. The Lakes are two small ponds surrounded by willow scrub and riparian forest. The site includes two parcels: (1) a 2.75-acre parcels of grassland, about 1,211 feet long and 100 feet wide, adjacent to the land side of the river and the riparian vegetation to the north and (2) a 2-acre, triangular-shaped, farmed parcel,

adjacent to the river levee and to the south of the Lakes. Reclamation District 900 has an easement to the 2.75-acre parcel, and the 2-acre parcel is privately held. Both parcels have access to water.

Site B. Site B, with 40 acres available for habitat development, lies on both sides of the cross levee forming the southern limit of the City of West Sacramento. The 15-acre portion on the south side has a deep pit that served as a disposal area for rice hulls and has since been quarried for organic material. Although the site is degraded, potential for restoration is high. The site would be suitable for marsh and open water establishment and riparian forest on the upper slopes. The remainder of the site, north of the cross levee, is a fallow agricultural field.

Site C. This 70-acre berm area, located west of the Ship Channel, is a proposed borrow site for the project. The Port has a permanent dredge disposal easement to this property, and it aha been used as a disposal site for dredged material from the Ship Channel. Although the site is on a shelf of land, it should be suitable for wetland development once borrow is removed and the site is recontoured. A temporary easement to use the site for borrow would be acquired during implementation of the project.

Site D. This 70-acre site is located within the Yolo Bypass downstream from the Sacramento Bypass. This portion of the Yolo Bypass is to the east of where most bypass floodflows pass and is protected by an extension of the Sacramento Bypass south levee. The land is now used for row crops. Wetlands and uplands would be developed west of a strip of riparian forest that parallels the water side of the levees that are to be improved. Water would be available either from ground water pumping or local drains. All 70 acres would be purchased to avoid severance damages that would occur with a smaller acquisition.

Although this land may be included in future development plans, such development is not imminent and does not justify deleting the site from consideration.

Site E. This 46-acre site, located 5 miles northwest of the Sacramento Bypass immediately west of the Sacramento River is surplus acreage from biological mitigation for the Sacramento Urban Area Levee Restoration Project. the site is actually two separate parcels with the Sacramento Urban mitigation site located between them. Because of its proximity to two mitigation sites now being developed, the site has excellent potential for habitat development. The Corps is currently developing land adjacent to the site into wetlands and uplands habitat. A second habitat area, which adjoins the Corps mitigation site, is being constructed as mitigation for the Lighthouse Marina, a private development. The site,

however, borders an intensively farmed area, which is a somewhat incompatible use because of pesticide spraying. (Site E is shown on Plate 12A).

Site F. This site is within a Yolo County park known as the Davis Communications Annex. It is located immediately north of the Yolo Communications Site Park about 3.5 miles south of Interstate 80 and is bordered on the west by County Road 104.

The park consists of 320 acres of which only 40 acres in the north half have currently been developed for recreation. However, according to the Davis Regional Park Master Plan, most of the north half of the park will eventually be developed, leaving the south half as open, undeveloped park land. The mitigation site has been proposed for the southeast corner of the park.

The entire park is a disturbed site which was previously agricultural land. It is dominated by thistle with existing trees and shrubs confined to the currently developed area. Therefore, the existing wildlife habitat is of low quality and there is low potential to support high quality wetlands and uplands habitat. Consequently, more than 52.5 acres would be needed at this site for mitigation.

In addition, the Davis Regional Park Master Plan indicates that there are several uses proposed for the park which would conflict with the mitigation site such as dog training and large group events. In particular, plans to develop the southeast corner of the park as a nature area with a trail directly conflicts with the proposal to develop a mitigation site. This property was deeded to Yolo County by the Department of the Bureau of Outdoor Recreation, to be used for public park and recreation purposes. Therefore, it is not clear whether the Secretary of the Interior would approve use of a portion of the park as a mitigation site. There is also concern that the mitigation site would eventually become isolated habitat surrounded by urban development. (Site F is shown on Plate 12B)

During Preconstruction Engineering and Design (PED), the Corps will determine if Site F is a cost-effective mitigation site.

EVALUATION OF FINAL ALTERNATIVE PLANS

No Action

The no action alternative assumes a 400-year flood control dam on the American River and repair of structural deficiencies in existing levees. Under this alternative, the City of West Sacramento would continue to experience the threat of flooding,

flood damages, and loss of life. However, the south Sacramento area, including Greenhaven, would have 400-year level of flood protection because the American River improvements would be implemented. The estimated flood damages in West Sacramento from the 100-, 200-, and 400-year floods would be about $693 million (October 1991 price levels). The primary source of flooding to the area is from the Yolo Bypass therefore, each flood event would essentially inundate the same area, resulting in essentially the same estimated flood damages. Average annual equivalent damages are estimated at $10 million.

100-, 200-, and 400-Year Alternatives

The major construction feature in these alternatives is increasing the heights of existing levees in the study area from a maximum of 4.5 feet for the 100-year plan to 5 feet for the 400-year plan. Raising levees around West Sacramento to provide project design levels of flood protection would reduce the probability of levee failure and overtopping in this area.

Construction Costs. Total estimated first costs for the various alternatives include all of the lands, easements, rights-of-way and relocations necessary for levee raising, as well as levee construction, environmental mitigation, engineering and design, and supervision and administration (see Table 7). First costs for the 100-, 200-, and 400-year alternatives of $15.9, $18.1, and $18.4 million, respectively.

Environmental Costs. Design of the three levee raising alternative plans attempted to minimize impacts to the environment by avoiding priority habitats such as wetlands and riparian forest. Impacts to valuable habitat were avoided by raising either the landward side or the waterward side of the levee for each reach, thereby minimizing disturbance to one side.

Unavoidable direct impacts for the three alternative plans would affect aquatic and riparian resources in the project area (see EIS\EIR). Construction activities impact grassland/agricultural, riparian forest, shrub/scrub, emergent marsh, and open water habitat types. Impacts to these habitat types would result from the clearing of vegetation on and adjacent to the levee to raise the levee height.

TABLE 7
ECONOMIC SUMMARY OF FINAL ALTERNATIVES PLAN
(Costs and Benefits in $1,000)

Alternative	First Costs 1	Annual Costs			Annual Benefits	B/C Ratio	Net Benefits
	Total	Annual Costs2	O/M&R Costs	Total			
100-Year	15900	1560	20	1580	7200	4.5	5620
200-Year	18100	1780	20	1800	8900	4.9	7100
400-Year	18400	1810	20	1830	9800	5.3	7970
400+-Year3	18400	1810	20	1830	9800	5.3	7970

1/ Includes costs for all lands, easements, right-of-way and relocations necessary for levee raising, as well as construction, engineering and design, supervision, administration, and mitigation.
2/ Discount rate 8-3/4% 100 year project life, October 1991 price levels.
3/ Estimated benefits based on 400-year levee alternative.

A formal Habitat Evaluation Procedure (HEP) analysis, including both direct and indirect impacts, was performed. For plan formulation purposes, environmental mitigation for direct impacts was estimated based on the value of the habitat type for wildlife and the length of time necessary to restore the compensation site to the maturity of the impacted area. In addition, at the time of the HEP analysis, the loss of vegetation from riprapping levees was not considered.

Since the design water-surface elevations and corresponding design levee elevations vary less than 1 foot between the 100- and 400-year alternatives, the extent of environmentally impacted areas varies little among the alternatives. Any of the alternatives would adversely impact approximately 11.9 acres of wetland and riparian habitat and a maximum of 29.1 acres of upland. Compensation for lost riparian forest and shrub/scrub impacts was estimated at a ratio of 3.3 to 1 for a total of about 39 acres of wetland and riparian vegetation. Grassland was assumed to be mitigated at a ratio of 0.45 to 1 for a total requirement of about 13 acres.

Compensation costs include planting and establishing riparian forest and shrub/scrub vegetation, excavating wetlands, and acquiring about 50 acres of land. Initial

environmental mitigation costs for the 100-, 200-, and 400-year alternatives total about $3.2 million for all plans. These costs were estimated based on completed projects with similar revegetation requirements and on land costs for 50 acres from a representative mitigation site in West Sacramento. Several sites within the city of West Sacramento were identified as suitable for mitigating environmental impacts of the alternatives.

The no action alternative assumed that the current trend to convert agricultural lands to residential and commercial development in West Sacramento would likely continue until 1992. In 1992, termination of the temporary A-99 zoning designation will require full compliance with Federal Emergency Management Agency (FEMA) standards for flood control and essentially preclude any further development because of the extreme flood depths and a lack of other practical flood-proofing measures. In contrast, all three levee alternatives will eliminate the FEMA restrictions to development and allow future planned development to occur as described in the City of West Sacramento General Plan (1990). This change in future land use would impact air quality, water quality, traffic, fish and wildlife, and the loss of prime and unique farmlands.

Benefits

For economic purposes, the existing level of protection in West Sacramento is approximately 70 years. The average annual equivalent damages under without-project conditions for West Sacramento are about $10 million. Average depths of flooding for the 100-, 200-, and 400-year floods are essentially the same and range from 3 to 16 feet within the boundaries of West Sacramento (see Plate 10). Benefits from with-project alternatives include inundation reduction, location, and flood insurance program benefits.

In accordance with planning guidance for determining flood damage prevention benefits in the freeboard range, benefits can be claimed for one-half of the area under the frequency-damage curve between the design level of protection and the largest flood that might be carried within the freeboard. Because of hydraulic assumptions upstream of the study area, no appreciable flow enters the Yolo Bypass beyond the 400-year flood. Therefore, the 400-year flood would essentially be the maximum flood possible in the study area. To derive additional benefits from the freeboard, benefits for each design (100-, 200-, and 400-year) were averaged with the benefits for the largest flood that can be carried within the freeboard (400-year). Equivalent average annual benefits, including benefits in the freeboard range are $7.2, $8.9, and $9.8 million for the 100-, 200-, and 400-year alternatives.

Summary of Costs and Benefits

As shown on Table 7, maximum net benefits occur at the 400-year level of protection. The table also indicates that because of hydraulic conditions in the system, annualized costs and benefits for the 400+-year plan are identical to the 400-year alternative. As mentioned previously, no appreciable flows enter the Yolo Bypass above the 400-year flood. Consequently, designs and costs for a greater than 400-year alternative would be the same as those for the 400-year alternative. Similarly, maximum benefits would occur at the maximum flood or maximum volume of water that can enter the study area and induce flood damage. Higher frequency events would also maintain the same level of benefits as the maximum flood or the 400-year level of protection.

An incremental analysis of the proposed mitigation sites identified Site D, the Yolo Bypass site, as the preferred site for purposes of formulating the final alternative plans. A graph of annual benefits and costs versus level of protection indicates the 400-year alternative as the NED plan (Plate 13).

NED/SELECTED PLAN

The NED plan, or the plan that maximized net benefits, is the 400-year levee alternative. In an August 1990 Executive Committee Meeting, the local sponsor (State of California) stated that it would support the NED plan as the Tentatively Selected Plan. Design features of this plan include raising and widening 5.7 miles of existing levees around West Sacramento along the east side of the Yolo Bypass and south side of the Sacramento Bypass a maximum of 5.5 feet. Final designs and cost estimates in Micro Computer Assisted Cost Estimating System (M-CACES) format were prepared. The project design is not intended to benefit the area downstream of the City of West Sacramento. The features of the plan are similar to the 400-year alternative design described in the alternatives section with the exception that hydraulic mitigation features are not included.

Levee features of the 400-year alternative would impact adjacent and downstream areas by reducing hydraulic conveyance and flood storage. Analysis of these impacts to determine if there was any significant consequential effect as a result of the upstream project indicated that implementation of the plan would not have significant hydraulic impacts on the existing system. Therefore, hydraulic mitigation measures were not required and are not a design feature of the Selected Plan.

CHAPTER V

SELECTED PLAN

PLAN DESCRIPTION

This chapter describes the components, accomplishments, and impacts of the Selected Plan (the NED plan), which provides the City of West Sacramento with 400-year flood protection.

Levee Improvements

Under the Selected Plan, about 5.7 miles of existing levees would be raised a maximum of 5.5 feet along the south side of the Sacramento Bypass and the east side of the Yolo Bypass from the Sacramento Bypass to the Ship Channel. The levee modifications are presented in Table 8, and their location is shown on Plate 14. Design levee crown elevations were based on the 400-year water surface profile and design freeboard criteria. Plate 15 shows a typical section for the proposed levee raising, and Plates 16 and 17 show the new levee crown profiles and stationing.

TABLE 8
SELECTED PLAN
DESCRIPTION OF PLAN MODIFICATIONS

Reach	Modified Reach Length (Miles)	Maximum Levee Height Increase (Feet)	Additional Right Of Way (Acres)	Remarks
Sacramento Bypass South Levee	1.0	5.0	2.5	Raise Levee Landside
Yolo Bypass East Levee Sacramento Bypass to SPRR[1]	1.1	5.5	4.1	Raise Levee Waterside
SPRR to I-80	1.0	5.0	4.2	Raise Levee Landside, Install Flood Gate at SPRR
I-80 to Ship Channel[2]	2.6	5.5	7.7	Raise Levee Landside

1/ Southern Pacific Railroad
2/ Sacramento River Deep Water Ship Channel

Relocations. The Southern Pacific Railroad and I-80 routes cross project levees in the reach of the proposed modifications (See Appendix D, Basis of Design). These structures would require major modifications if they were raised to the elevations of the new levees.

The Southern Pacific Railroad grade is approximately 1 foot above the proposed design water surface. Modification of the railroad to pass over the proposed increased levee heights would require raising several miles of railroad line and trestles at great expense. Instead of raising the railroad, the plan proposes that a flood gate, with concrete walls on both sides and running parallel to the tracks, be installed at the railroad crossing. The walls would abut the levee, and a concrete sill would be installed for the tracks between the walls. A gate, which would be closed and sealed during floods, would be constructed between the walls. The proposed gate is similar to those currently in use in other reaches of the Sacramento River Flood Control Project.

The effects of increased water surfaces on Southern Pacific Railroad bridges were also considered. These bridges are currently wooden trestles, with a double track east-west rail line. The Southern Pacific Transportation Company has indicated that it is planning to replace the existing trestles with steel pile and concrete cap and deck trestles, which are considered adequate to withstand the small (less than 1 foot) increases in water surface resulting from proposed levee modifications. The 1986 flood substantially encroached upon the wooden trestles, and no structural problems occurred during the flood.

The grade of I-80 is approximately 4 feet above the proposed design water surface elevations. As with the railroad, any modification of this crossing would be expensive. The existing crossing is a wide concrete bridge, and the 4-foot freeboard is considered adequate. The concrete roadway would serve to prevent any wavewash from passing over the levee at this crossing. The parapet walls on both sides of the roadway are high enough to give 6 feet of freeboard at the roadway crossing. This low point in the levee reach would not jeopardize the integrity of the levee system.

Two existing telephone lines in the proposed construction areas would need to be relocated. A telephone line at the southern end of the Sacramento Bypass runs adjacent to the levee alignment for about 1,000 feet. A second telephone line crosses the levee alignment just downstream of I-80. No additional lands are needed for these relocations.

Borrow Sites. A total of about 825,000 cubic yards of fill will be required for construction of the Tentatively Selected Plan. Plate 18 identifies two possible borrow sites: (1) a 40-

acre area within the Sacramento Bypass could provide the approximately 265,000 cubic yards of fill needed to raise levees along the east side of Yolo Bypass north of the Southern Pacific Railroad tracks and along the south side of the Sacramento Bypass and (2) a 70-acre section along the Ship Channel could provide the additional 560,000 cubic yards of material needed for the east levee of the Yolo Bypass south of the railroad tracks. In addition, about 47,000 cubic yards of riprap will be required for the proposed project. The riprap will be obtained from commercial quarries.

Environmental Mitigation Features

Planning for mitigation of potential adverse environmental impacts began during plan formulation by locating the flood control facilities to avoid fish and wildlife habitat. For the Tentatively Selected Plan, levees were raised either landside only or waterside only to avoid critical habitats such as wetlands and riparian forest.

The mitigation requirement includes the creation of a combination of wetlands and uplands habitat types totaling 52.5 acres. Additional acreage acquisition may be required to avoid severance damages that would occur with smaller acquisition.

Of the 52.5 acres, 39.4 acres will be wetlands habitat (a combination of riparian forest, emergent marsh, and scrub/shrub). The acreage for each habitat type will be determined in the design stage. The 13.1 acres to replace upland habitat may be any upland or wetland cover or habitat type. Mitigation would include reestablishment and maintenance of the habitat types for 3 years, after which maintenance would be the responsibility of the local sponsor (California State Reclamation Board). Under state law the Reclamation Board would relinquish maintenance authority to the California Department of Fish and Game.

An Incremental Analysis identified Site D, the Yolo Bypass site, as the preferred site for purpose of formulating the Selected Plan (see DEIS/EIR). This proposed site was selected primarily on the basis of habitat suitability and proximity to the proposed construction site. It was determined that this site could support high quality wetlands and uplands habitat. Soil types and availability of water were critical factors that affected site suitability. The proposed Site D meets the above outlined environmental criteria. However, it is recognized that land uses may change and other factors may influence mitigation site selection. Therefore, final site selection is a tentative process. If Site D is unobtainable the alternative mitigation sites will be reanalyzed during the Preconstruction, Engineering and Design (PED) phase of the study for the purpose of selecting an alternative site.

PLAN ACCOMPLISHMENTS

Based on levee failure assumptions developed for economic analyses, existing project levees provide West Sacramento about 70-year level of flood protection. With a levee failure, almost the entire area of West Sacramento could be inundated up to depths of 16 feet. Without-project flood damages for all floods greater than 70 years (existing level of protection) are approximately $700 million. Average annual equivalent damages, based on October 1991 price levels and an 8-3/4 percent interest rate, are approximately $10 million.

The Selected Plan satisfies all planning objectives of the study; that is, the plan reduces potential flood damages adjacent to the Sacramento River and Yolo Bypass in the urban areas of West Sacramento, while preserving environmental and cultural resources in the study area. In conjunction with the Selected Plan for the American River Watershed Investigation and other existing flood control facilities, the plan would provide an approximately 400-year level of flood protection to West Sacramento area.

Benefits include inundation reduction, location, and flood insurance program benefits. Because of the carrying capacity of the system upstream of the study are, no appreciable additional flow enters the Yolo Bypass for flood exceeding 400 years. Essentially, the Selected Plan achieves the maximum average annual equivalent benefits of $9.8 million (October 1991 price levels). This includes $8.3 million for inundation reduction, $1.4 million for location, and $0.1 million for flood insurance program benefits.

DESIGN AND CONSTRUCTION CONSIDERATIONS

Table 9 lists the levee design details for the different levee reaches. Levee cross section designs remained the same as that used in past levee design since these levee sections performed adequately, and a stability analysis determined that the levees would be stable after being raised to the elevations proposed for the Selected Plan (see Appendix E). The south levee of the Sacramento Bypass allows public access to the top of the levee. The top width of this levee will be the minimum safe roadway width of 28 feet. Determining whether new levee fill would be on the landside or waterside was based on the quality of fill to be placed and impacts on utilities, relocations, development, and the natural environment.

Design freeboard was modified slightly from what was discussed earlier in the technical studies section for the Sacramento Bypass. Since the wave action of the Yolo Bypass does not reach into the upper reaches of the Sacramento Bypass,

design freeboard along this upper reach was reduced to 4 feet along the upper 2,000 feet of the Bypass. The freeboard is increased to 6 feet along the lower reach where the sacramento Bypass joins the Yolo Bypass. Design freeboard along the Yolo Bypass was held at 6 feet to the Ship Channel where it was reduced to 4 feet.

Erosion potential along the modified levees and the need for erosion protection were also considered. Initially the 4 to 1 side slopes were thought to be sufficient to eliminate the need for wavewash protection. However, after further investigation of the erosion which took place during the 1986 flood, consideration of the wave height potential in the Yolo Bypass, and coordination with Reclamation District 900, the need for erosion features were reconsidered. Field investigation showed that riprap for wavewash protection already exists along most reaches of the levee. This riprap extends from the toe of the levee to about 4 feet from the top of the levee. It was therefore decided that a 12-inch blanket of riprap will be placed to tie into the existing riprap, which extends from the toe to about 4 feet from the top for most levees, and will extend up to 2 feet from the top. The concrete lining on the reach of the east levee of the Yolo bypass between the Southern Pacific Railroad and I-80 will be removed and replaced with riprap when the levee is raised to insure congruous protection against wavewash along all reaches.

TABLE 9
SELECTED PLAN
DESIGN DETAILS FOR LEVEE REACHES

		Side Slopes	
Reach	Top Width (Feet)	Land Side (H:V)	Water Side (H:V)
Sacramento Bypass South Levee	28	2:1	3:1
Yolo Bypass East Levee Sacramento Bypass to SPRR[1]	20	3:1	4:1
SPRR to I-80	20	3:1	4:1
I-80 to Ship Channel[2]	20	3:1	4:1

1/ Southern Pacific Railroad
2/ Sacramento River Deep Water Ship Channel

OPERATION AND MAINTENANCE

OPERATION

As described earlier, a flood gate will be constructed at the Southern Pacific Railroad crossing along the east side of the Yolo bypass. This gate will remain open until flood elevations reach a predetermined critical elevation, at which time it will be closed and sealed until flood elevations drop below the critical elevation.

Flood elevations do not rise rapidly in the Yolo bypass, and the critical flood elevation will be selected to give adequate time to close and seal the flood gate. As proposed, the gate itself will be entirely within the levee freeboard and will not have floodwater against it unless design flows are exceeded. A monitoring system will be installed to alert local officials when flood elevations reach the critical elevation, and the flood gate closure will be carefully monitored during the flood's passage. Although the flood gate could interrupt railroad traffic for several days, such an interruption would be infrequent. These types of flood gates which are manually operated, are currently in use in other reaches of the Sacramento River Flood Control Project.

No operation is required the for remaining proposed project features such as raised levees and environmental mitigation.

Maintenance

The Corps will prepare an Operation and Maintenance Manual describing maintenance requirements for the completed work. Levee maintenance activities could include maintaining a patrol road and a grassy cover, with no woody vegetative growth, and periodically inspecting for animal borings and other anomalies.

Maintenance costs for flood control features and fish and wildlife improvements will be charged in accordance with provisions of Title 33, Flood Control Regulation, Maintenance and Operation of Flood Control Work, approved by Secretary of the Army, on August 9, 1944, and published in the <u>Federal Register</u> on August 17, 1944. The general intent of the regulations is as follows:

The structures and facilities constructed by the United States for local flood protection shall be continuously maintained in such a manner and operated at such times and for such periods as may be necessary to obtain the maximum benefits.

ENVIRONMENTAL IMPACTS

Direct Impacts

The Selected Plan was developed to minimize environmental impacts to priority habitats such as wetlands and riparian forest. By raising either the landward or waterward side of the levee, disturbances to the alternate side would be minimized. Areas impacted by the Selected Plan are indicated in Table 10.

Mitigation activities to minimize adverse construction impacts include controlling dust, muffling equipment noise, avoiding the use of residential and other sensitive areas as transportation routes to and from the work site, and limiting construction work hours.

The most significant direct impact of the Selected Plan would be the permanent loss of natural vegetation and wildlife habitat. (A detailed discussion is included in the EIS/EIR.) The proposed levee work would affect habitat by (1) building out the base of the levee to accommodate the raised height, thus enlarging the levee "footprint," (2) periodically clearing the permanent right-of-way, delineated as a 10-foot strip of land extending from the toe of all the levees, and (3) adding riprap to waterside slopes on the Yolo Bypass east levee. The existing levee slope, which is protected with riprap or concrete that effectively diminishes vegetative growth, was not considered a direct loss or impact in the mitigation analysis. The HEP analysis did count losses, primarily upland grasses, for other slope areas which have no riprap or have riprap that has not reduced vegetative growth.

Construction would temporarily disturb grasses and small shrubs on levee slopes that would be cleared of vegetation and then reseeded. In addition, construction activities would damage habitat in a temporary construction right-of-way, extending 25 feet beyond the 10-foot permanent right-of-way, but reseeding would bring this area back to preproject conditions.

TABLE 10
IMPACTED AREAS FOR THE SELECTED PLAN

Direct Permanent Impacts	Impacts (acres)	Mitigation (acres)
Wetlands (Riparian Forest & Shrub/scrub)	11.9	39.4
Upland Grassland	29.0	13.1
Total	40.9	52.5
Temporary Impacts		
Upland Grasslands	149.8	0

Mitigation for direct impacts was estimated on (1) the value of the habitat type for wildlife and (2) the length of time necessary to restore the mitigation site to the maturity of the impacted area.

The U.S. Fish and Wildlife Service estimated the mitigation ratio for riparian forest in the project area at a ratio of 3.3 to 1. The forest is mature and highly valuable to wildlife, and the mitigation area would take at least 50 years to reach comparable habitat value.

Mitigation for shrub/scrub was estimated at 3.3 to 1. This habitat is also important to wildlife, and riparian shrub/scrub is essentially a younger stage of riparian forest. Permanent direct impacts would be mitigated by developing and managing the 52.5 acres described earlier. The predominant habitat type would be riparian forest, which is a high quality resource that must be replaced in-kind. In excess of 11 acres is lost due to the project.

The plan's mitigation area could be up to 70 acres (including contingency acreage) which for cost estimating purposes, would be developed as follows: 40 acres of riparian forest, 10 acres of emergent marsh, 10 acres of shrub/scrub and grasslands and the possible acquisition of 10 acres as an uneconomic remnant.

The proposed mitigation site for the Selected Plan is located in the Yolo Bypass immediately south of the Sacramento Bypass and west of the east levee that is to be raised. The existing land use here is agriculture/cropland (see Plate 12, Site D).

Indirect Impacts

Indirect impacts are related to land use changes that may occur as a result of project implementation. As proposed, the Selected Plan would remove the Federal Emergency Management Agency's moratorium on development, thus making growth possible. The economic analysis for without-project assumed no growth after 1992 because of the A-99 zoning of most of the city within the 100-year flood plain. Without the Selected Plan or similar plan to achieve a minimum 100 year level of flood protection, the A-99 zoning would be eliminated in 1992, and the regular flood insurance program would be implemented. At this time, compliance with the National Flood Insurance Program, coupled with the extent and depths associated with the 100-year flood plain, would preclude further development. The Corps is responsible for identifying the project's likely indirect impacts, as well as potential mitigation. Actual mitigation for impacts of induced future development will be the responsibility of the local agencies controlling development in the project area. Since the extent and timing of these indirect impacts will be determined in the context of the local land use planning process, it is appropriate that this process address mitigation issues as well. The local agencies are expected to provide assurances as to how they will exercise their planning authority to avoid or minimize indirect impacts. These assurances are discussed in Chapter 23 of the EIS/EIR. The State and local interests have provided their plans for mitigation of growth-inducing impacts as part of the Memorandum of Understanding found in the EIR/EIS.

With project implementation, urban development is expected to occur at a rate consistent with the State of California Department of Finance population projections and employment projections, availability of land in West Sacramento, and concurrent development of necessary infrastructure. The land use assumptions are outlined in Appendix A - Land Use and Chapter 5 of the EIR/EIS. Growth was projected based on the City of West Sacramento General Plan (1990), which identifies future land use patterns that simulate maximum buildout of the area. Much of the new development will affect open space and agricultural lands. The Corps estimated the loss of vacant land and accompanying wildlife habitat and natural vegetation at about 3,400 acres over the life of the project. Specific procedures would be developed on the preservation of cultural and historic resources, wetlands, fish and wildlife resources, endangered species, and air quality.

The West Sacramento General Plan EIR identified mitigation measures for the impacts of development. The Corps, has prepared a plan to avoid and mitigate direct impacts and disclose indirect impacts to the valley elderberry longhorn beetle; this plan is in accordance with the Endangered Species

Act (see EIR/EIS Chapter 23). Similarly, the local sponsor, in consultation with local agencies including the State Department of Fish and Game, has prepared an MOU for avoiding and mitigating impacts to Swainson's hawk and giant garter snake. In addition, the EIS/EIR contains an MOU which addresses indirect impacts to Fish and Wildlife. (See EIS/EIR Appendices H and F).

ECONOMICS OF THE TENTATIVELY SELECTED PLAN

A 100-year project life (1998 to 2098) was used to compare final costs and benefits and to analyze environmental and economic impacts and benefits for the Tentatively Selected Plan. Project economics were based on October 1991 price levels, an 8-3/4 percent interest rate, a 100-year life of the project, and a 2-year construction period beginning in 1996. First and annual project costs are summarized in Table 11, and costs and benefits in Table 12. Detailed information on project benefits and costs is presented in Appendix A, Economics, and Appendix D, Basis of Design, respectively. Appendix D includes a breakout of costs for the Federal and non-Federal components and a description of the "Code of Accounts Cost Estimating" procedures that were used to estimate project costs. Real estate costs are summarized in Appendix F, Real Estate.

Operation and maintenance costs represent the average cost of maintaining the project over its 100-year life, including maintenance and periodic renovation of the additional levee, operation and maintenance of the gate across the Southern Pacific Railroad, and maintenance of mitigation areas.

Based on known expenditures for similar projects, costs would average $20,000 annually.

As shown in Table 12, net economic benefits are estimated at about $8.1 million. Benefit categories include inundation reduction, location, and flood insurance program benefits. The benefit-cost ratio is 5.7 to 1. Based on existing development the benefit-cost ratio is 4.9 to 1.

TABLE 11
SELECTED PLAN COST ESTIMATE
(October 1991 Price Levels)

First Cost

Item	Description	Cost
01	Lands	$1,880,000
02	Relocations	15,000
06	Fish and Wildlife Facilities	2,400,000
11	Levees	10,200,000
18	Cultural Resource Preservation	131,000
30	Planning, Engineering and Design	1,665,000
31	Construction Management	1,132,000
	Project First Cost	**$17,423,000**

Annual Cost

Total First Costs	$17,423,000
Interest During Construction	1,560,000
Total First Investment	18,983,000
Interest Rate	8.750%
Analysis Period (years)	100
Interest and Amortization	1,660,000
O,M&R Costs	20,000
Total Annual Costs	**$1,680,000**

TABLE 12
ECONOMIC SUMMARY OF SELECTED PLAN

Items	$ Millions
First Cost	17.4
Annual Cost	1.7
Annual Benefits	9.8
Net Benefits	8.1
Benefit-Cost Ratio	5.7

RISK AND UNCERTAINTY

Whether the Selected Plan provides the accomplishments described depends on the validity of the assumptions and analytical elements used in the study; the accuracy of base data; the successful completion of future studies, designs, and construction; and appropriate operation and maintenance after construction. Several significant study elements and the estimated relative risk and/or uncertainty associated with them are described below.

Sacramento River Flood Control System Evaluation

The without-project condition assumes that the following features of the Sacramento River Flood Control System Evaluation are in place. The probability of successful completion and operation of this evaluation is high because of strong Congressional and local support.

- Construction of phase I, Sacramento Urban Area Improvements, was initiated and is scheduled for completion in 1992; this assumption is therefore relatively certain.

- Phase II, Marysville-Yuba City Area, includes remedial repairs of levees along the Yuba and Feather Rivers to return them to design standards. If phase II work was not assumed to be in place, levee failures would occur earlier during the flood event but it would not impact events in excess of the 100-year flood. Therefore, although phase II work has not yet been approved for construction, initial hydraulic studies indicate that reconstruction of these upstream levees to the system design level would not significantly affect the design flows in the Yolo Bypass in the vicinity of West Sacramento or the feasibility of the project.

- Phase III, Mid-Valley Area, recommends remedial repairs along the east levee of the Yolo Bypass north of Sacramento Bypass, including raising the existing levee crown elevation in low areas to prevent overtopping. Results of phase III studies indicate that certain increments of levee reconstruction work are not economically feasible and may not be approved. The assumption that phase III work is not in place will not impact the feasibility or plan formulation of the Selected Plan. The most likely scenario would be failure of the east levee of the Yolo Bypass into the Elkhorn area. However, this failure would not affect maximum stages in the Yolo Bypass because high volumes in the bypass and the duration of flow elevations are essentially the same for the 200- and 400-year floods.

Phase III work would increase flood protection to the Elkhorn Slough area, which has an existing level of protection of 20 years. The design level for the 100, 200 and 400-year floods with or without Phase III work will remain the same. This is because a levee failure would cause the area to fill primarily to a 100 year event. Implementation of phase III would not affect the plan formulation of the Selected Plan.

- Phase IV, Lower Sacramento Area Reconstruction, would provide increased protection to the lower Sacramento area, specifically to the area south of the City of West Sacramento to Rio Vista. With the system in place, the level of protection is raised to 30 years. Implementation of this project would not affect the feasibility or formulation of the Selected Plan.

- Phase V, Upper Sacramento Area, would provide increased protection to the upper reaches of the Sacramento River including the federal levees north of Knights Landing. Initial hydraulic studies indicate that reconstruction of these upstream levees to the system design level would not significantly affect the design flows in the Yolo Bypass in the vicinity of West Sacramento or the feasibility of the Selected Plan.

American River Watershed Investigation

The Sacramento Metropolitan Area Study assumes that the Selected Plan proposed for the American River Watershed Investigation is in place. The likelihood of the American River project being authorized is very high because the area's level of flood protection is significantly below 100 years, and the flood plain is occupied by about 400,000 people and $36 billion in damageable property. Although the proposed American River project and Sacramento Metropolitan project can function independently, the study areas for both projects are hydraulically interrelated, in addition, the projects are to be combined during preconstruction engineering and design.

- The Selected Plan for the American River Feasibility Investigation provides a 200-year flood protection. With a 200-year design project on the American River, 400-year flood will result in floodflows into the American River of about 240,000 cfs below Folsom Dam. Hydrologic analysis determined that levee failure would occur at 240,000 cfs and that the resultant flow at the mouth of the American River would be about 180,000 cfs. This flow, combined with the concurrent 100-year Sacramento River flow, would result in a levee failure at river mile 50, downstream of the cross levee south of West Sacramento, so that flows through this break would not produce flood damages in West Sacramento. In addition, a

break at river mile 50 allows flooding on the West Sacramento side and not into the highly urbanized area of south Sacramento. However, the south Sacramento area would experience flooding from the levee breaks on the American River. Additional levee work for south Sacramento is therefore not required.

- The proposed Auburn storage facility reduces the amount of levee raising required around West Sacramento for the Selected Plan and dismisses the need for proposing added levee work along the Sacramento River for protection to south Sacramento.

- Without an American River Watershed project, the 100, 200, and 400-year floods on the Sacramento River, would produce levee failures on the Sacramento River at river mile 50. If there is a failure at river mile 50, there would be no failures along the Sacramento River adjacent to West Sacramento. These failures are based on Corps failure criteria. If the proposed American River project was not constructed, the Sacramento Metropolitan Area Study Selected Plan would still be feasible, and the levee raising improvements would still provide in excess of 150-year protection to the City of West Sacramento. However, the south Sacramento area would maintain its existing 70- to 80-year level of protection.

- The American River Watershed Investigation includes a detention basin in northeast Natomas as a hydraulic mitigation in the final selected plan, it will not affect the feasibility or plan formulation of the Sacramento Metropolitan Area Study Selected Plan.

Stage-Frequency Relationships

The development of the stage-frequency relationships was based on various assumptions, base data, and modeling techniques used in the study. The details of the hydrologic and hydraulic analysis are included in Appendix C. Assumptions concerning upstream levee failures for extreme events along the upper Sacramento River would impact floodflows and stages in the project area. These assumptions were based on historic events, existing levee conditions, and expected rainfall-runoff amounts. The modeling results and design profiles are considered reasonable and appropriate for this study.

Induced Flooding

The Selected Plan does not include hydraulic mitigation measures to offset any induced flooding downstream. Results of the hydraulic impact analysis indicated that impacts from the

Selected Plan to the depth, duration, and frequency of flooding to the existing system were not significant. During a 400-year flood event hydraulic analysis indicates that implementation of the plan would result in a flood elevation increase which varies from 0.4 foot to 1.1 feet downstream areas. Of particular concern was the risk assessment associated with increased flooding to the Yolo County Landfill and City of Davis Wastewater Treatment Plant. Based upon the information developed under the Yolo Bypass Reconnaissance study there is an existing flood threat and potential flood damages to the Treatment Plant and Landfill. The Treatment Plant and Landfill are located in the Willow Slough Bypass area. Both facilities are subject to flooding from potential levee failures on the north Willow Slough Bypass levees. The non-damaging event was assumed to be the 20-year flood event. For the 100-year flood event average depth of overland flow affecting the landfill would be $\leq$ 3 feet and would last for less than 3 days. The landfill appears to be outside the ponding area for this type of flooding. Even considering the above outlined damages potential hydraulic mitigation measures were not found to be economically feasible. The risk that the Selected Plan would induce flooding is low.

Residual Flooding

The Selected Plan provides a 400-year level of flood protection to the West Sacramento area. Over the 100-year life of the project, the probability of a flood exceeding the design level of protection is about 21 percent. The probability of a flood exceeding the design level over a 30-year period is about 8 percent. These figures support an acceptable level of risk. In addition, the local sponsor supports the level of protection being proposed and understands the level of residual risk.

Interior Flooding

The risk of interior flooding in the study area would continue with implementation of the Selected Plan. The City of West Sacramento has an existing interior drainage system for the existing levees. This system was recently analyzed for the City's general plan. The area within the City is divided into eight major drainage sheds which encompass about 12,000 acres. Three reclamation districts serve the City's trunk storm drainage and flood protection needs. The current interior drainage system is composed of storm drain laterals and trunks which drain to canals that either drain to the Ship Channel or to pumping stations. These stations pump water to either the Yolo Bypass, the Ship Channel, or the Sacramento River. The drainage canals are large enough to serve as storage or detention basins.

The City of West Sacramento General Plan has investigated improvements to the drainage system, which will be necessary as planned development occurs. In most cases, these improvements are designed to limit the 100-year elevations within the drainage system. These improvements include larger trunk lines and additional pumping stations. None of these improvements are necessary because of the proposed Selected Plan.

The proposed raising of the levees does not alter the existing drainage patterns or the current operation of the existing system. No modifications to the drainage system are proposed as part of the Selected Plan. There are no additional risks to interior drainage anticipated as a result of the proposed project.

Sedimentation

With respect to the impacts of sediment deposited in the Yolo Bypass, it is estimated that about 460,000 cubic yards of sediment are deposited annually in the Bypass. If spread uniformly over the surface area of the Bypass, this amount would represent a depth of about 0.05 inch per year or 5 inches in a 100-year period. The estimated impact of sediment on the design is considered to be minimal and well within the 6 feet of freeboard used in the Selected Plan.

Environmental Mitigation

The uncertainty of adequately offsetting adverse impacts to environmental resources resulting from project construction is low, primarily because (1) a detailed analysis was performed and coordinated with various agencies, (2) conservative estimates of replacement needs were used, and (3) success of mitigation efforts will be monitored and enforced according to the required mitigation plan. The State of California, Reclamation Board is engaged in ongoing negotiations with various environmental agencies with the purpose of developing a mitigation plan for indirect impacts to the Swainson's Hawk in West Sacramento. A summary of these ongoing negotiations is included in the EIS/EIR, and accompanying Memorandums of Agreement.

Project Cost

The degree of confidence in the estimated project cost is considered to be high. Contingencies, which average overall about 20 percent and are considered reasonable, have been included in the cost estimate. The detailed Cost of Accounts Cost Estimating procedures were used for the Selected Plan.

CHAPTER VI

PLAN IMPLEMENTATION

IMPLEMENTATION REQUIREMENTS

Report Review and Approval

This final Feasibility Report will be extensively reviewed by Federal, State, and local agencies as well as by private groups and individuals. The Corps will submit this final report to its Washington Level Review Center, publish a public notice of completion of the study (providing a 30-day review period), and file the final EIS/EIR with EPA. The Washington Office will coordinate all public and internal reviews, and the Board of Engineers for Rivers and Harbors will make a recommendation on the project to the Chief of Engineers. The Chief of Engineers will submit the report to the Assistant Secretary of the Army, who, in turn, will transmit the report for Office of Management and Budget comments before submittal to the Congress.

Engineering and design studies will be initiated after publication of the public notice of completion of study. The results of these studies will be used to prepare plans and specifications for the project. These studies will initially be conducted at Federal expense, but will ultimately be added to the project construction cost and shared with the non-Federal sponsor (along with the costs of other project features).

This final Feasibility Report and EIR/EIS is scheduled for Washington-level review by March 1992.

PROJECT AUTHORIZATION

Once the Feasibility Report is approved and the project is authorized, construction funds will be required. The project will be considered for inclusion in the President's budget based on (1) national priorities, (2) magnitude of the Federal commitment, (3) economic and environmental feasibility, (4) level of local support, (5) willingness of the non-Federal sponsor to fund its share of the project cost, and (6) budgetary constraints that may exist at the time of funding. Federal budget recommendations will be based on evidence of support by the State of California, who is the non-Federal sponsor, and the State's ability and willingness to provide its share of the project cost. Once the Congress appropriates the Federal share of funds, the Assistant Secretary of the Army (Civil Works) and the non-Federal sponsor will sign a Local Cooperation Agreement, which will define the Federal and non-Federal responsibilities

for implementing, operating, and maintaining the project according to requirements established by the Congress and the administration.

If the project is authorized in 1992, construction activities could be started as early as 1996 and be completed in 1999.

COST-SHARING REQUIREMENTS

Federal Responsibilities

Following completion of the final Feasibility Report and EIR/EIS and authorization of the project by Congress, the Federal Government will finalize designs, prepare detailed plans and specifications, and construct the project after funds are appropriated and non-Federal interests provide the 5 percent cash contribution, lands, relocations and assurances for the non-Federal cooperation requirements.

Non-Federal Responsibilities

Current Federal regulations require non-Federal participation in the financing of projects. In accordance with the Water Resources Development Act of 1986, the non-Federal sponsor will:

- Provide without costs to the United States all lands, easements, and rights-of-way necessary for construction and maintenance of the flood control and associated mitigation measures, including all necessary relocations and alterations of buildings, utilities, roads, bridges(except railroad bridges), sewers, irrigation diversions, and related special features.

- Hold and save the United States free from damages resulting from construction and subsequent maintenance of the project, except for damages which are caused by the fault or negligence of the United States or its contractors, and if applicable, adjust all claims concerning water rights.

- Maintain, operate, repair, replace, and rehabilitate all completed work, without cost to the United States, in accordance with regulations prescribed by the Secretary of the Army. Monitor the status of completed mitigation and provide periodic reports on its condition and repairs and replacement if needed.

• Provide a cash contribution of 5 percent of the total project cost and an additional cash contribution, if necessary, to bring the non-Federal share to a minimum of 25 percent of the total project costs, with credit given for lands, easements, rights-of-way, and relocations. The non-Federal contribution shall be made concurrently and proportionally with Federal expenditures for project construction.

• Comply with the provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646, 84 Stat. 1894), as amended.

• Publicize flood plain information in the area concerned and provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to ensure compatibility between future development and protection levels provided by the project.

• Participate in and comply with applicable Federal flood plain management and flood insurance programs.

• Comply with the provisions of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (Public Law 96-510, 42 USC 9601-9675). Specifically, the non-Federal sponsor must assume complete financial responsibility for the cleanup of any hazardous material located on project lands and regulated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and be responsible for operating, maintaining, repairing, replacing, and rehabilitating the project in a manner so that liability will not arise under CERCLA.

Federal and non-Federal obligations and requirements will be defined in a Local Cooperation Agreement signed prior to initiation of construction. The non-Federal funds will not have to be provided until after the Congress authorizes the project and appropriates construction funds and a Local Cooperation Agreement is signed. Payment of the funds will be made at intervals during construction.

COST APPORTIONMENT

Based on current Corps regulations, Federal participation is limited to the Federal share of the cost of the NED plan. Accordingly, Table 13 shows the estimated Federal and non-Federal costs for the Selected Plan.

FINANCIAL ANALYSIS

The State of California (through the Reclamation Board) has a plan for financing the non-Federal costs of a project. It includes authorization (Section 12657 of the California Water Code) for the State to pay for lands, easements, rights-of-way, and relocations on Federally authorized flood control projects in the Sacramento and San Joaquin Valleys. The State, in cooperation with other non-federal agencies, will pay all of non-Federal capital costs, including the 5-percent cash requirement, lands, easements, rights-of-way and relocations, and ensure that the project will be maintained to Federal standards. (See Appendix G - Financial Plan).

TABLE 13
SELECTED PLAN
SUMMARY OF PROJECT FIRST COSTS

	Federal	Non-Federal	Total
Lands and Damages 1/	180,000	1,700,000	1,880,000
Relocations	---	15,000	15,000
Fish & Wildlife Facilities	2,400,000	---	2,400,000
Levees and Floodwalls	10,200,000	---	10,200,000
Cultural Resources Preservation 2/	131,000	---	131,000
Planning, Engineering and Design	1,660,000	5,000	1,665,000
Construction	1,130,000	2,000	1,132,000
Subtotal	15,701,000	1,722,000	17,423,000
Non-Federal Cash Contribution	-2,601,000	+2,601,000	
Project First Cost	13,100,000	4,323,000	17,423,000

1/ Federal administrative costs for non-Federal land acquisition.
2/ Cultural Resources Preservation costs associated with mitigation and/or data recovery up to one percent of the total Federal costs are not subject to cost sharing

The Reclamation Board will be responsible for the operation, maintenance, and repair of the completed project. State law requires the Board to pass on these responsibilities and their costs to the local beneficiaries of the project.

Maintenance activities will be provided by the local agencies, who currently obtain funds through existing benefit assessment districts.

The Board, as the non-Federal sponsor for the feasibility study and likely non-Federal sponsor for the proposed project, will furnish funds for the State's share of project costs by appropriations made by the State Legislature.

VIEWS OF OTHERS

In general, local agencies, organizations, and individuals support the selected plan. The Letter of Intent from the State Reclamation Board is contained in Chapter X of this document.

There is some disagreement between the FWS and Corps on the level of environmental impact and mitigation for inclusion in the selected plan. The issue specifically concerns secondary impacts which may result from construction of the Selected Plan. This issue and mitigation responsibility is described in more detail in the EIS/EIR.

CHAPTER VII

PUBLIC INVOLVEMENT

This chapter describes the scoping and public involvement process used to gain input from agencies and the public for use and consideration in the draft and final Feasibility Report/EIS/EIR.

The Corps initiated the public comment period with publication of a Notice of Intent in the August 31, 1989, Federal Register. The State published a Notice of Preparation on October 13, 1989. A public information meeting was held in West Sacramento on December 2, 1989, to describe study alternatives and objectives, outline the schedule, answer questions, and gather public comments and concerns on the issues and alternatives to be analyzed. All individuals, organizations, and agencies were invited to attend, and Congressman Vic Fazio participated, indicating his support for flood control improvements in the study area.

In 1989 and 1990, the Corps conducted an intensive public awareness program, making more than 100 presentations to the news media, government officials, environmental groups, trade and fraternal organizations, and agencies to explain the Sacramento area's flood control problems and seek comment from diverse audiences on solutions and concerns. Many of these presentations were also open to the general public. This program included potential flooding problems and alternative solutions in the West Sacramento study area.

The Corps also established and encouraged public use of a toll-free telephone number to answer questions or make comments on the various flood control studies in the Sacramento area. The number was announced at Corps presentations, public meetings, and on local television stations.

The Notice of Availability for the draft Feasibility Report/DEIS/EIR was published in the Federal Register, in November 1991. Verbal and written comments on the draft EIS/EIR were accepted at a public hearing held December 10, 1991. A transcript of the hearing can be found in Appendix H. In addition to the public hearing two public workshops, were held on December 2 and 4, 1991. The draft feasibility document was circulated for public and agency review in November 1991. At the close of the comment period, 13 comment letters were received. These comments and their responses are contained in the Comments and Responses Appendix.

CHAPTER VIII

CONCLUSIONS

Feasibility evaluations of the Sacramento Metropolitan area indicate that the City of West Sacramento has less than a 100-year level of flood protection. The south Sacramento area (including Greenhaven) adjacent to the Sacramento River has a level of flood protection of 100 years or greater from potential flooding from the Sacramento River. For all areas within the study area, it is assumed that existing levees are structurally stable under existing design conditions.

The stage-frequency analyses conducted in this study indicate that the recurrence interval of the February 1986 flood was about 70 years for the Sacramento River and Yolo Bypass in the study area. Minimum levee embankment freeboard observed during the February 1986 flood event was 1.4 feet for West Sacramento on the Sacramento River side and 2.0 feet for West Sacramento on the Yolo Bypass side. However, the lower spot on the Sacramento River side is being raised through current local development along the river. Design freeboard for the system is 3 feet and 6 feet on the Sacramento River and Yolo Bypass, respectively. These minimum observed freeboards and the estimated recurrence interval of the 1986 flood suggest a level of protection for West Sacramento significantly less than 100 years.

With- and without-project conditions for the study assume that the Selected Plan for the American River Watershed Investigation is implemented. Consequently, the flood threat to West Sacramento and south Sacramento from the American River was considered in a sensitivity analysis during the formulation of alternatives for this study. This analysis determined the impacts to West Sacramento if the proposed American River flood control facility was built or not and the formulation of higher levels of flood protection.

Four flood control alternatives were formulated by (1) identifying and evaluating a variety of flood control measures and (2) developing final alternatives based on feasible measures. Potential measures included modifying existing weirs, modifying existing levees, diversion facilities, storage facilities, deepening or enlarging channels, and nonstructural measures. The only measure that was technically, economically, and environmentally feasible was to modify existing levees.

The final alternatives included the no action alternative and 100-, 200-, and 400-year plans of levee raising for increased flood protection for West Sacramento. Preliminary economic analyses indicated that levee raising improvements for the City

of West Sacramento were economically justified with benefit-to-cost-ratios of 4.5, 4.9, and 5.3 for the 100, 200, and 400-year plans. The estimated first costs are $15.9, $18.1, and $18.4 million. Optimization analysis of the 100-, 200-, and 400-year alternatives resulted in selection of the 400-year alternative plan as the NED Plan. With local support, the NED plan was chosen as the Selected Plan.

The Selected Plan features include raising 5.7 miles of existing levee on the east side of the Yolo Bypass and the south side of Sacramento Bypass a maximum of 5.5 feet and creating and managing 39.4 acres of wetland and 13.1 acres of uplands habitat to mitigate for adverse environmental impacts. The results of the hydraulic impact analysis indicate that potential increases to depth, duration, and frequency of flooding to downstream areas as a result of implementation of the Selected Plan are not significant. Based on this analysis, hydraulic mitigation features are not included as design features in the Selected Plan.

The total first cost of the Selected Plan based on a detailed analysis (M-CACES) is estimated at $ 17.4 million (October 1991 price levels). Total annual costs of the plan are estimated at $ 1.7 million. The average annual equivalent benefits at an interest rate of 8-3/4 percent are estimated at $9.8 million, yielding a benefit-cost ratio of 5.7 to 1.0.

There is strong local support for a plan that would provide a high level of flood protection to the area, while minimizing any potential adverse environmental impacts. The State of California, as well as County, City, and other local agencies, are actively cooperating in the development of an acceptable plan. The local sponsor has indicated a willingness and capability to share project costs and assume operation and maintenance of the completed project.

CHAPTER IX

PROPOSED RECOMMENDATION

After carefully considering the environmental, social and economic effects, as well as engineering feasibility, of all plans, I recommend that the plan selected herein for flood control be authorized for implementation as a Federal project, with such modifications as in the discretion of the Commander, Headquarters Office of the U.S. Army Corps of Engineers, may be advisable, and subject to cost sharing and financing arrangements satisfactory to the President and the Congress as prescribed in Section 106 of the Water Resources Development Act of 1986 (Public Law 99-662). The project would include the raising of 5.7 miles of existing levee around West Sacramento a maximum of 5.5 feet, and the implementation of 52.5 acres of environmental mitigation. The total initial Federal cost is presently estimated at $17.4 million (October 1991 price level).

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. These recommendations do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program, nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding.

Laurence R. Sadoff
Colonel, Corps of Engineers
District Engineer

CHAPTER X

LETTER OF INTENT

STATE OF CALIFORNIA—THE RESOURCES AGENCY PETE WILSON, Governor

THE RECLAMATION BOARD
1416 Ninth Street, Room 455-6
Sacramento, CA 95814
(916) 653-5434

Colonel Laurence R. Sadoff
District Engineer
Sacramento District
U. S. Army Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

Dear Colonel Sadoff:

The Reclamation Board indicates our intent by this letter, as conditioned below, to be the nonfederal sponsor for the flood control project recommended in the Sacramento Metropolitan Area Final Feasibility Report and Environmental Impact Statement/ Environmental Impact Report.

The selected plan contemplates 5.7 miles of levee raising on federal project levees along the east side of the Yolo Bypass and the south side of the Sacramento Bypass. The selected plan would increase the level of flood protection in the West Sacramento area from the current 70-year level to a high level of protection. The urgent need for these levee improvements is described in the combined project feasibility report and environmental impact statement/environmental impact report.

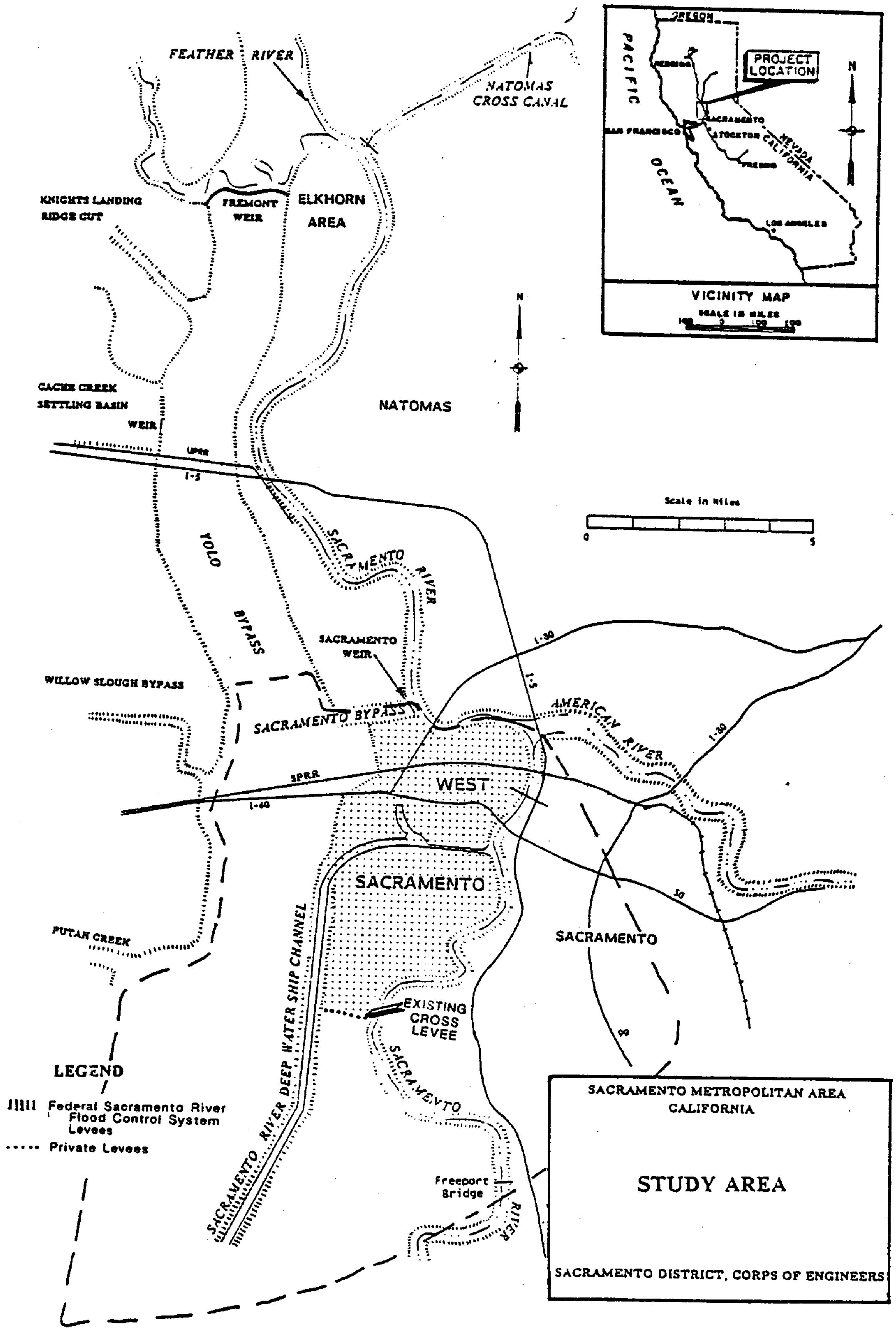
Subsequent to federal, State, and local authorization and appropriation, and only after completion of the review process required under the California Environmental Quality Act, the Board will enter into a local cooperation agreement to provide all nonfederal requirements for lands, easements, rights of way, relocations, and cash contributions as required and in accordance with the Water Resources Development Act of 1986 (PL 99-662). Submittal of this letter of intent is not an obligation of future unappropriated State funds by the California Legislature.

If you have any questions, please have your staff contact Raymond Barsch, General Manager of The Reclamation Board, at (916) 653-5434 or Peter Rabbon, Program Manager for Flood Control Activities Under Reclamation Board Authority, at (916) 653-6075.

Sincerely,

Wallace McCormack
President

PLATES



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

STUDY AREA

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

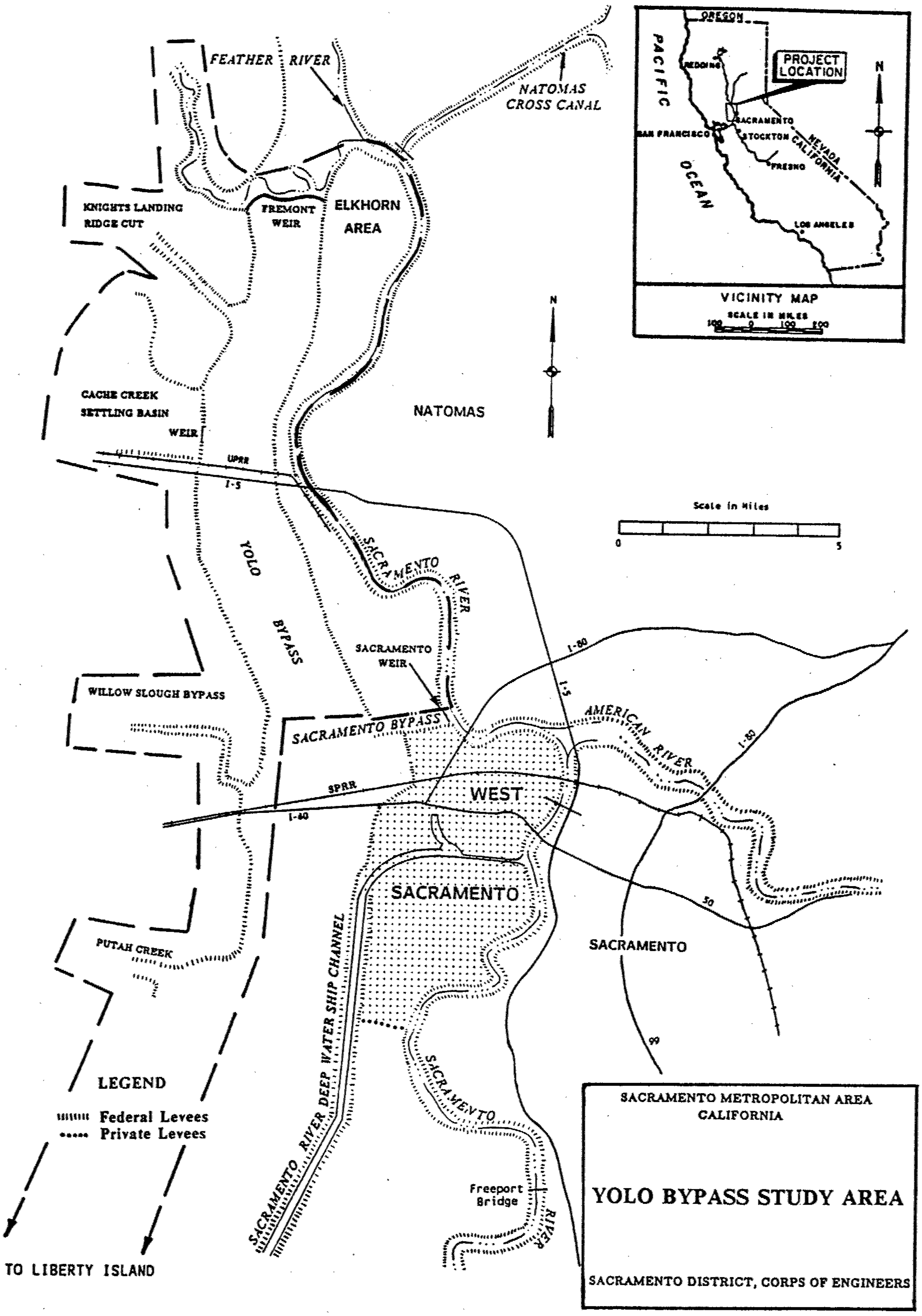
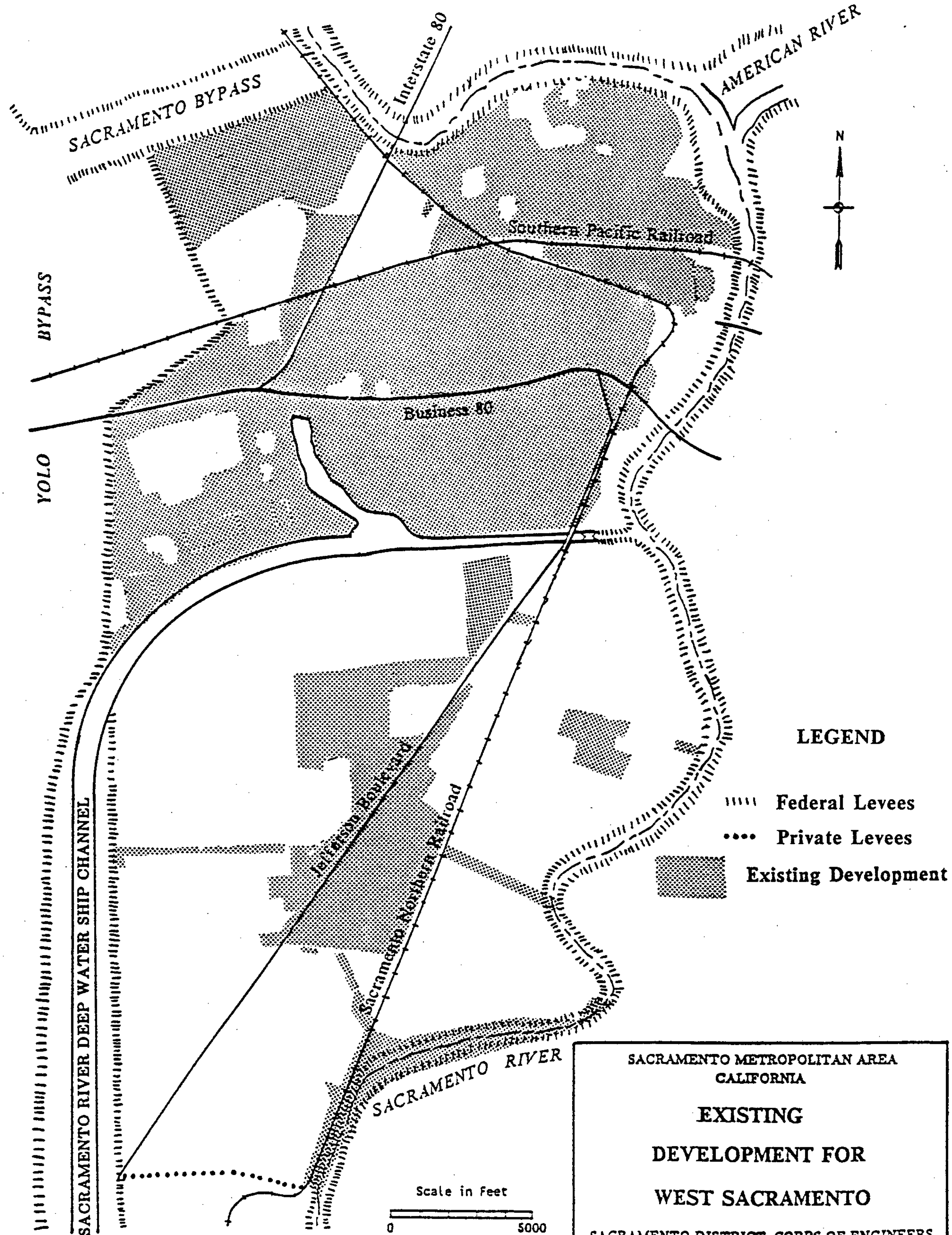

FEATHER RIVER
NATOMAS CROSS CANAL
OREGON
PACIFIC
OCEAN
PROJECT LOCATION
N
REDDING
SACRAMENTO
SAN FRANCISCO
STOCKTON
NEVADA
CALIFORNIA
FRESNO
LOS ANGELES
VICINITY MAP
SCALE IN MILES
KNIGHTS LANDING RIDGE CUT
FREMONT WEIR
ELKHORN AREA
CACHE CREEK SETTLING BASIN
WEIR
NATOMAS
N
UPRR
I-5
Scale in Miles
0
5
YOLO
BYPASS
SACRAMENTO RIVER
SACRAMENTO WEIR
I-80
I-5
WILLOW SLOUGH BYPASS
SACRAMENTO BYPASS
AMERICAN RIVER
I-80
SPRR
WEST
I-80
SACRAMENTO
50
SACRAMENTO
PUTAH CREEK
99
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
SACRAMENTO
LEGEND
Federal Levees
Private Levees
Freeport Bridge
RIVER
TO LIBERTY ISLAND
SACRAMENTO METROPOLITAN AREA
CALIFORNIA
YOLO BYPASS STUDY AREA
SACRAMENTO DISTRICT, CORPS OF ENGINEERS

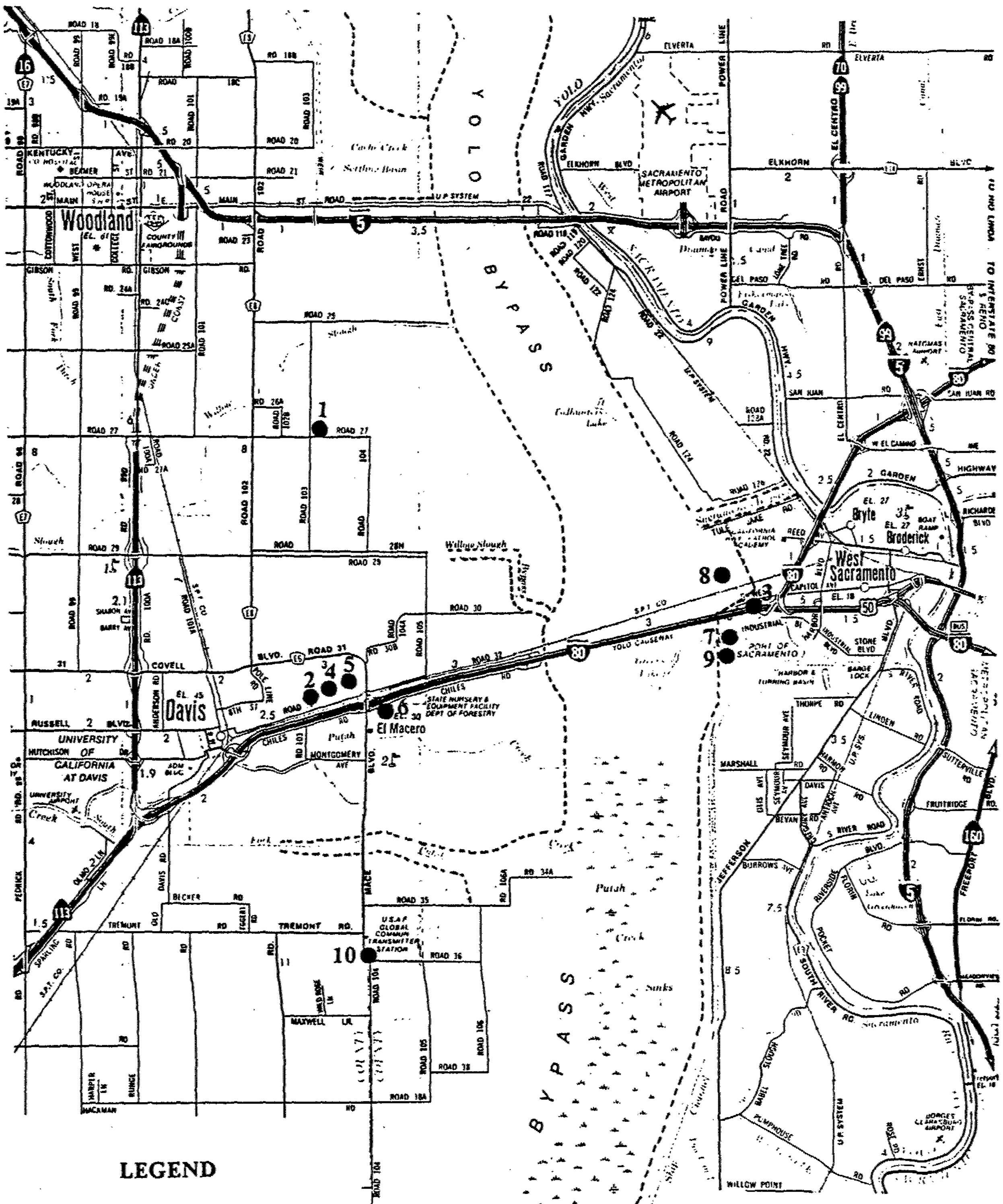
PLATE 2



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

EXISTING DEVELOPMENT FOR WEST SACRAMENTO

SACRAMENTO DISTRICT, CORPS OF ENGINEERS



LEGEND

Existing Levees

Hazardous and Toxic Waste Sites

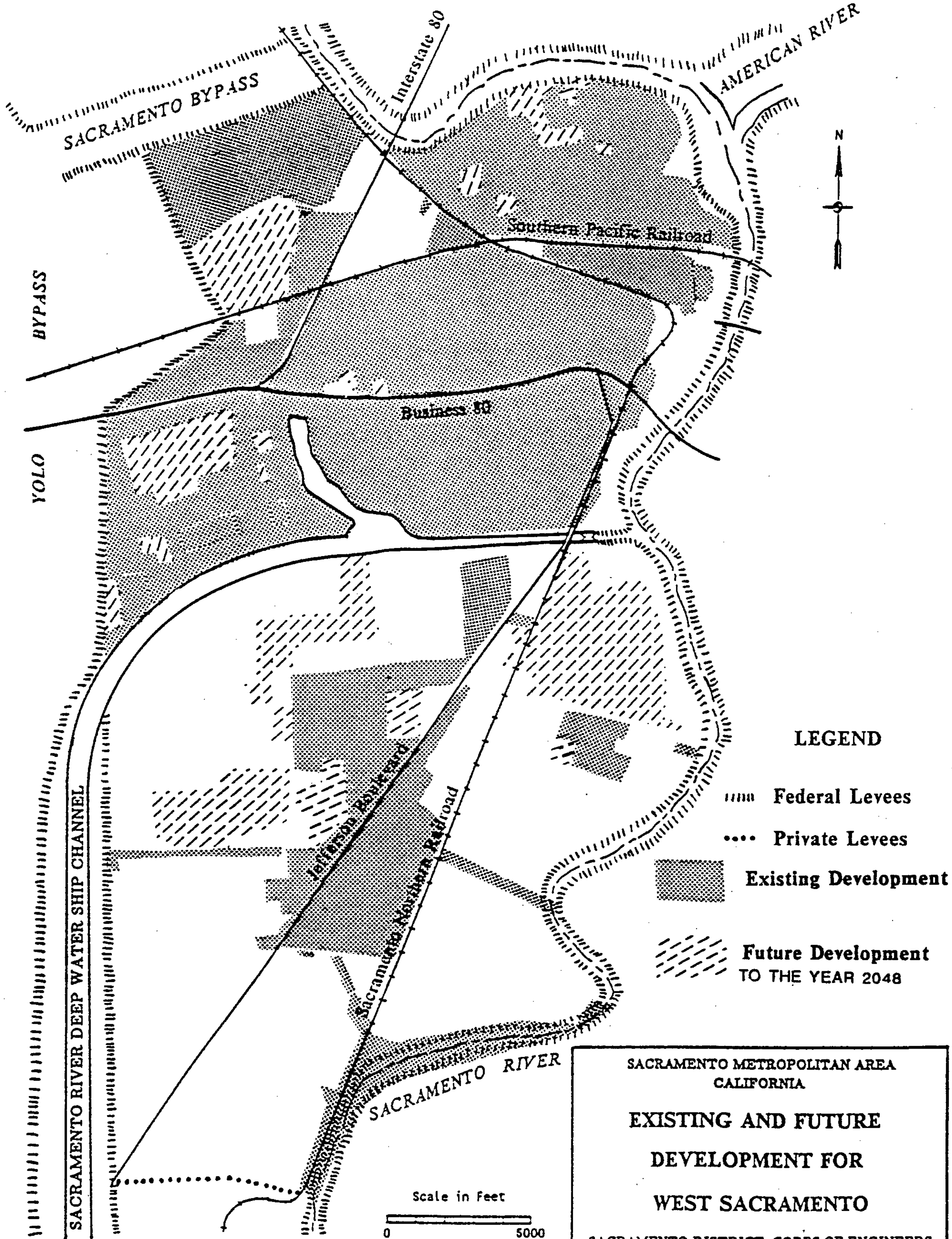
Scale in Miles

0 5

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

HAZARDOUS AND TOXIC WASTE SITES

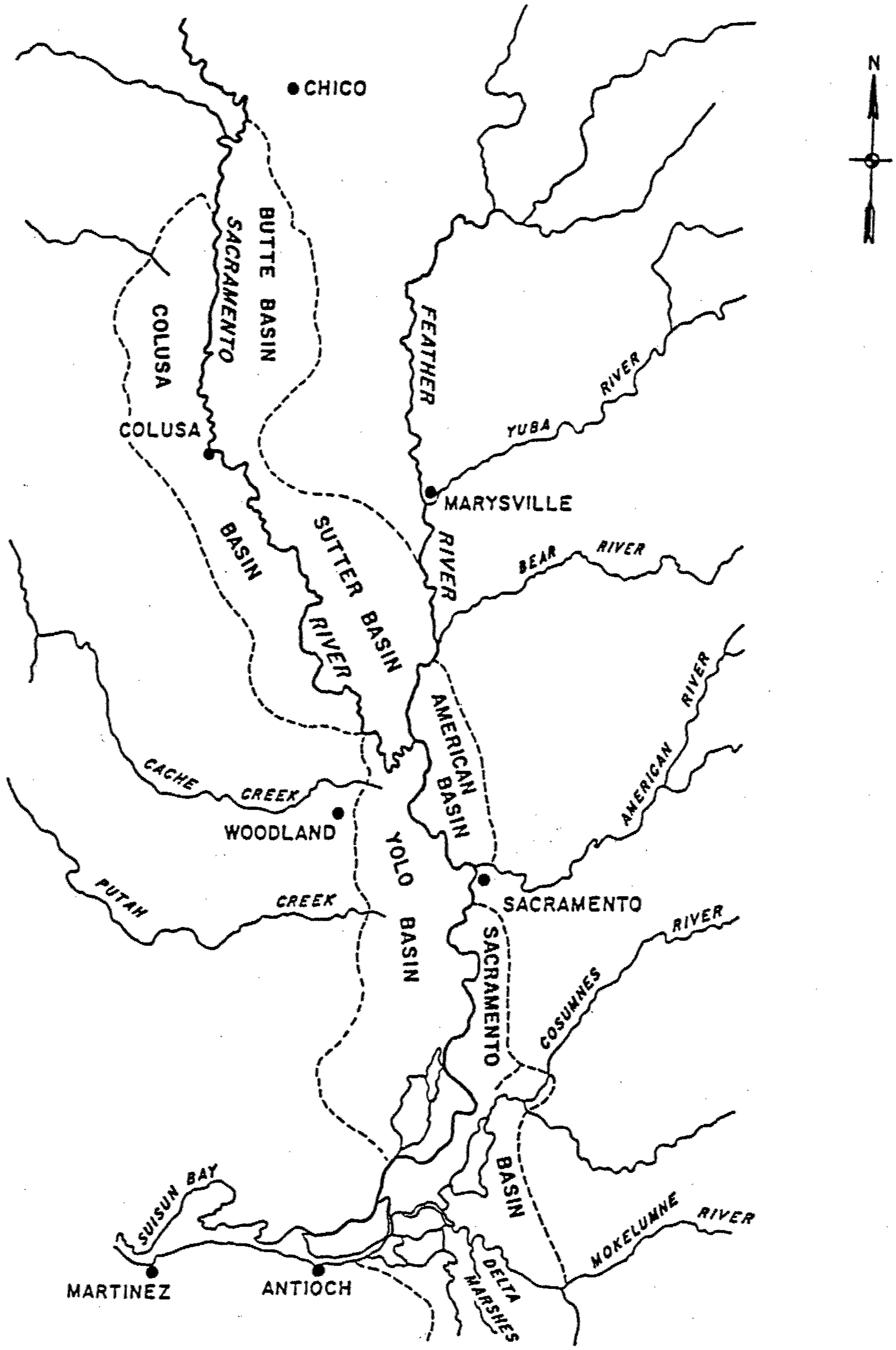
SACRAMENTO DISTRICT, CORPS OF ENGINEERS



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

EXISTING AND FUTURE DEVELOPMENT FOR WEST SACRAMENTO

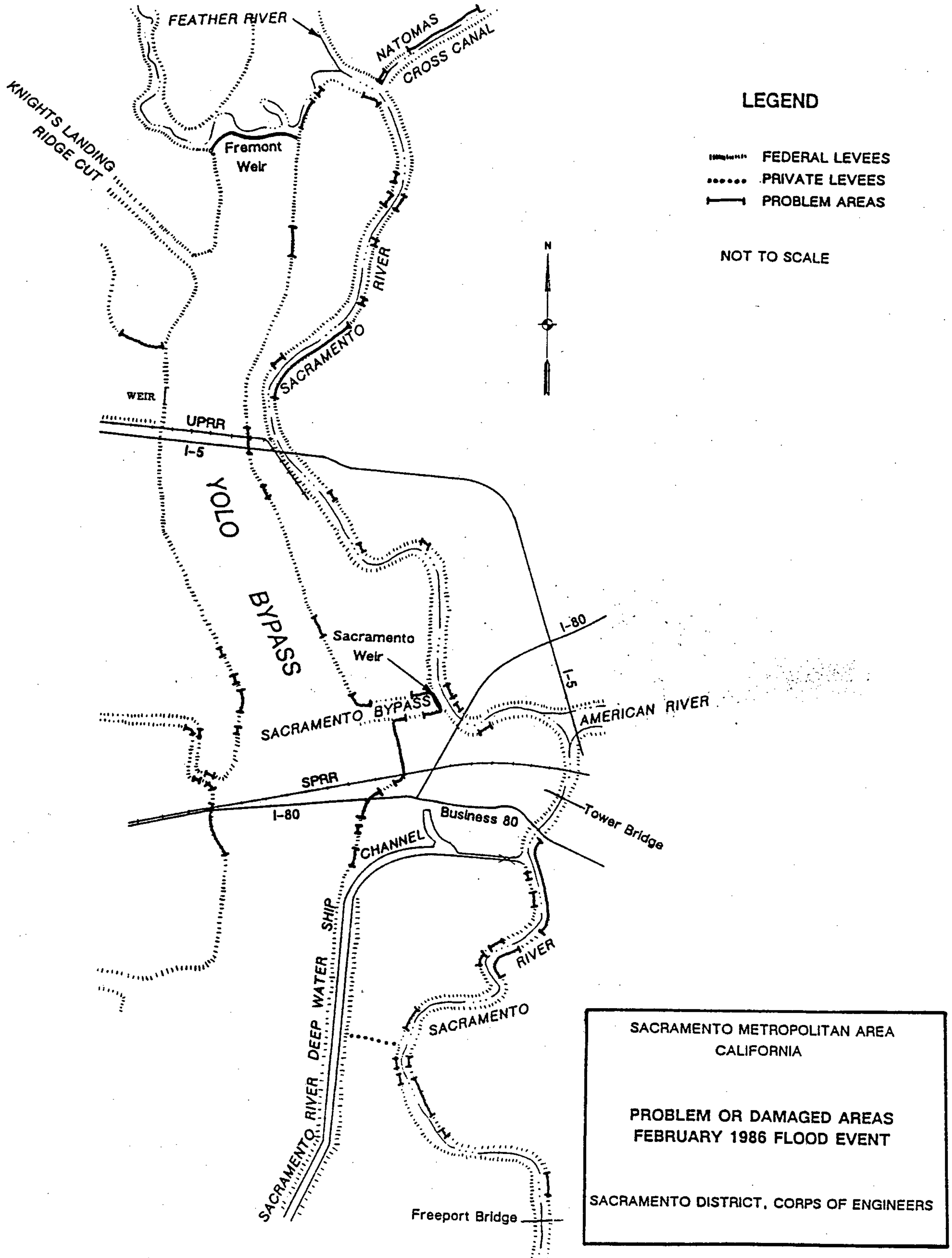
SACRAMENTO DISTRICT, CORPS OF ENGINEERS

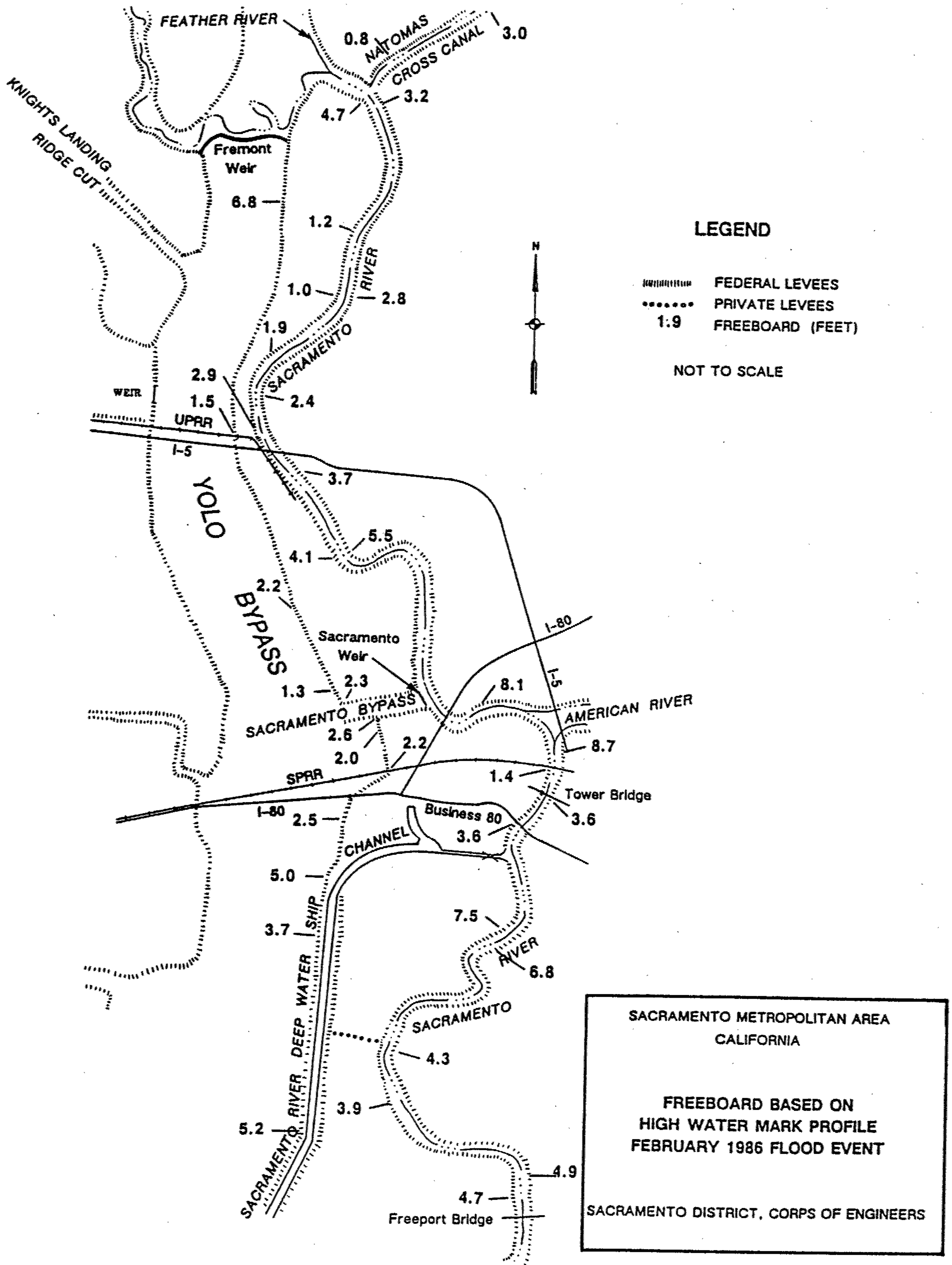


SACRAMENTO METROPOLITAN AREA
CALIFORNIA

HISTORICAL FLOODBASINS OF THE SACRAMENTO VALLEY

SACRAMENTO DISTRICT, CORPS OF ENGINEERS


FEATHER RIVER
NATOMAS CROSS CANAL
KNIGHTS LANDING RIDGE CUT
Fremont Weir
SACRAMENTO RIVER
WEIR
UPRR
I-5
YOLO BYPASS
Sacramento Weir
SACRAMENTO BYPASS
I-80
AMERICAN RIVER
SPRR
Business 80
Tower Bridge
CHANNEL
SACRAMENTO RIVER DEEP WATER SHIP
Freeport Bridge
N
LEGEND
FEDERAL LEVEES
PRIVATE LEVEES
PROBLEM AREAS
NOT TO SCALE
SACRAMENTO METROPOLITAN AREA
CALIFORNIA
PROBLEM OR DAMAGED AREAS
FEBRUARY 1986 FLOOD EVENT
SACRAMENTO DISTRICT, CORPS OF ENGINEERS


FEATHER RIVER
NATOMAS CROSS CANAL
0.8
3.0
4.7
3.2
KNIGHTS LANDING RIDGE CUT
Fremont Weir
6.8
1.2
1.0
SACRAMENTO RIVER
2.8
1.9
2.9
1.5
2.4
WEIR
UPRR
I-5
3.7
YOLO BYPASS
5.5
4.1
2.2
Sacramento Weir
I-80
1.3
2.3
8.1
AMERICAN RIVER
SACRAMENTO BYPASS
2.6
2.0
2.2
8.7
SPRR
1.4
Tower Bridge
3.6
I-80
2.5
Business 80
3.6
CHANNEL
5.0
7.5
SACRAMENTO RIVER DEEP WATER SHIP
3.7
SACRAMENTO RIVER
6.8
4.3
3.9
5.2
4.9
4.7
Freeport Bridge
LEGEND
FEDERAL LEVEES
PRIVATE LEVEES
1.9 FREEBOARD (FEET)
NOT TO SCALE
N
SACRAMENTO METROPOLITAN AREA
CALIFORNIA
FREEBOARD BASED ON
HIGH WATER MARK PROFILE
FEBRUARY 1986 FLOOD EVENT
SACRAMENTO DISTRICT, CORPS OF ENGINEERS

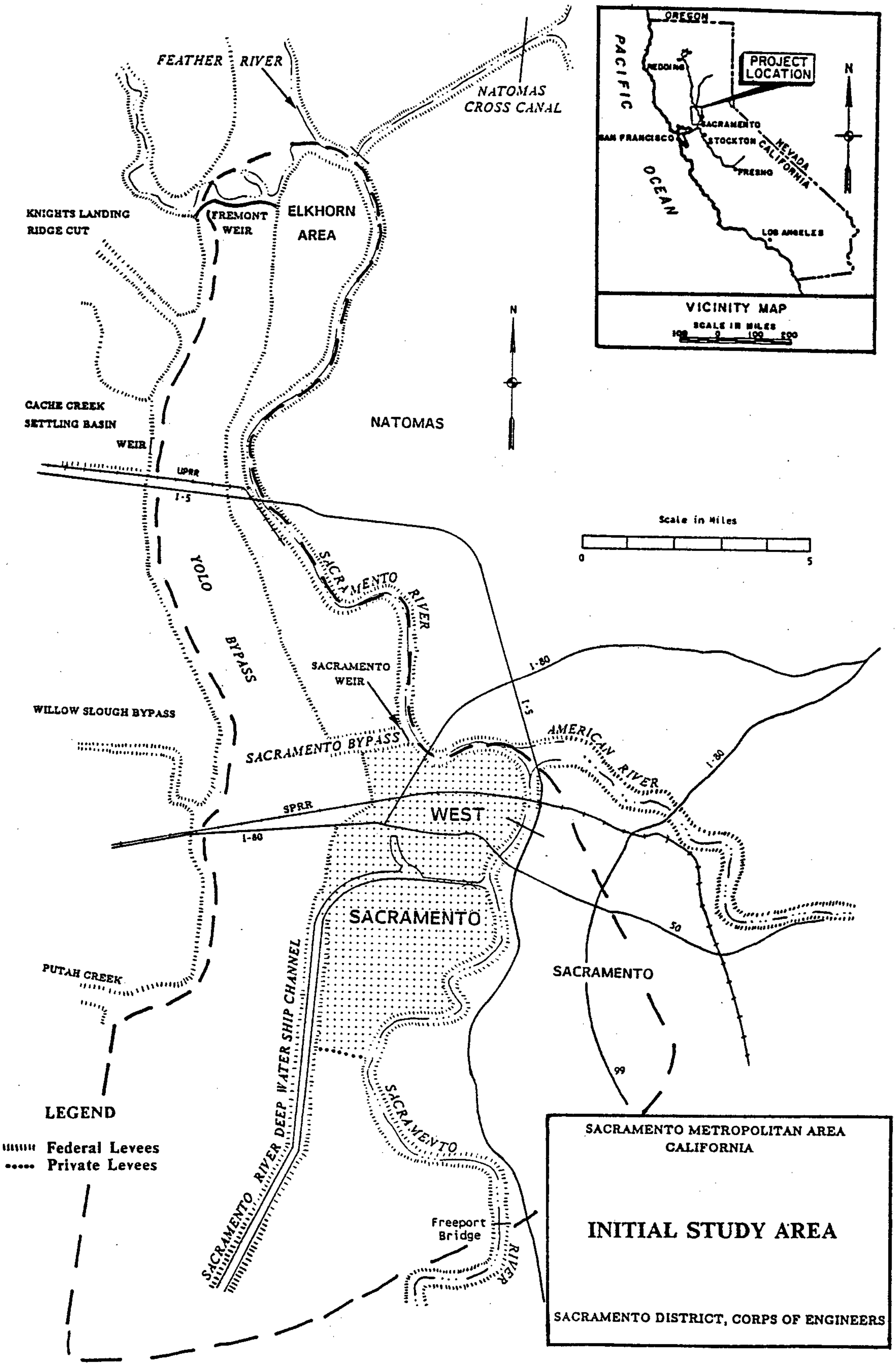
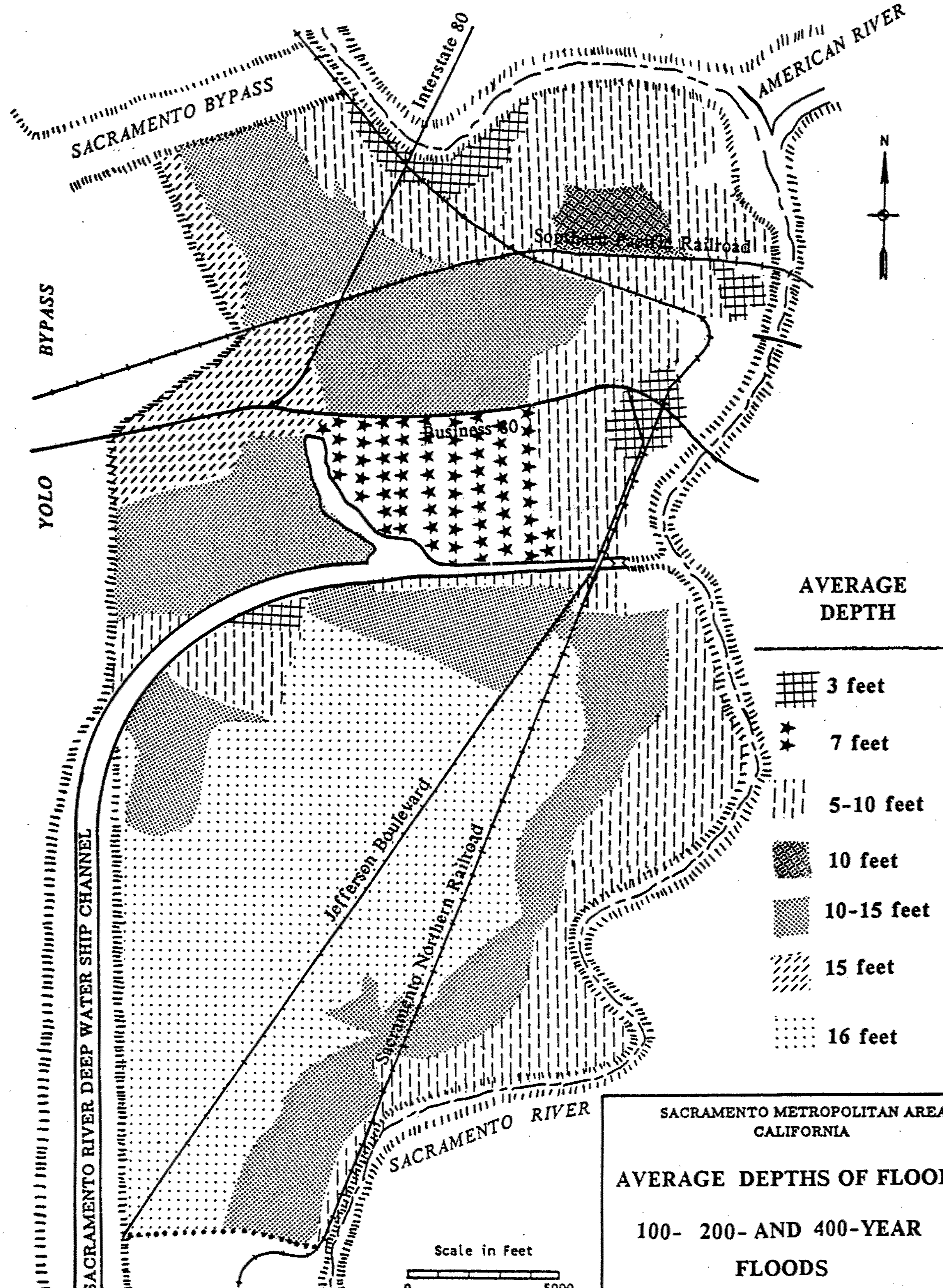

FEATHER RIVER
NATOMAS CROSS CANAL
KNIGHTS LANDING RIDGE CUT
FREMONT WEIR
ELKHORN AREA
CACHE CREEK SETTLING BASIN
WEIR
NATOMAS
UPRR
I-5
YOLO
BYPASS
SACRAMENTO RIVER
Scale in Miles
0
5
SACRAMENTO WEIR
WILLOW SLOUGH BYPASS
SACRAMENTO BYPASS
AMERICAN RIVER
I-80
SPRR
WEST
SACRAMENTO
50
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
PUTAH CREEK
99
LEGEND
Federal Levees
Private Levees
Freeport Bridge
OREGON
PACIFIC
OCEAN
REDDING
PROJECT LOCATION
SACRAMENTO
SAN FRANCISCO
STOCKTON
FRESNO
NEVADA
CALIFORNIA
LOS ANGELES
N
VICINITY MAP
SCALE IN MILES
100 0 100 200
SACRAMENTO METROPOLITAN AREA
CALIFORNIA
INITIAL STUDY AREA
SACRAMENTO DISTRICT, CORPS OF ENGINEERS

PLATE 9

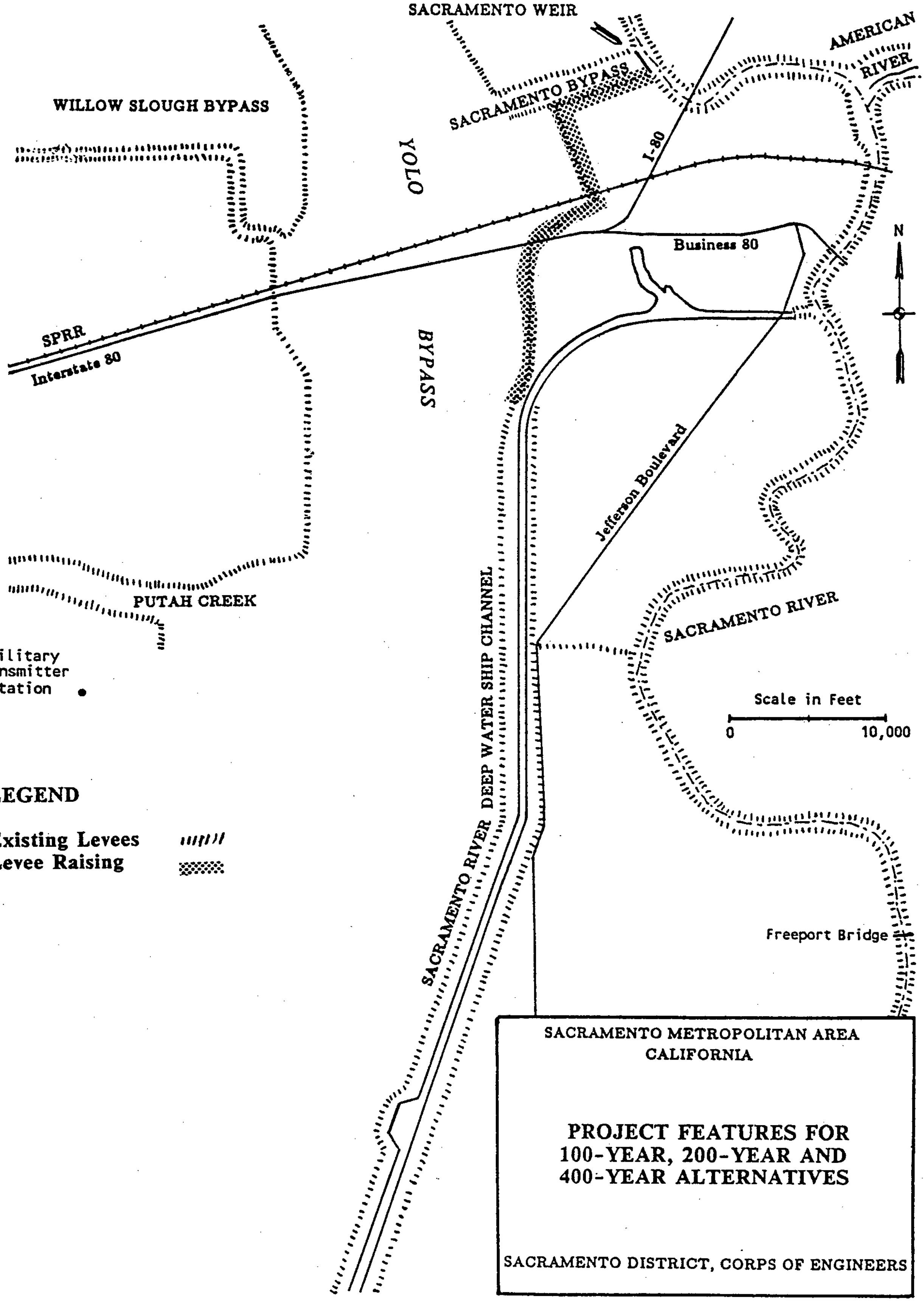


SACRAMENTO METROPOLITAN AREA
CALIFORNIA

AVERAGE DEPTHS OF FLOODING

100- 200- AND 400-YEAR FLOODS

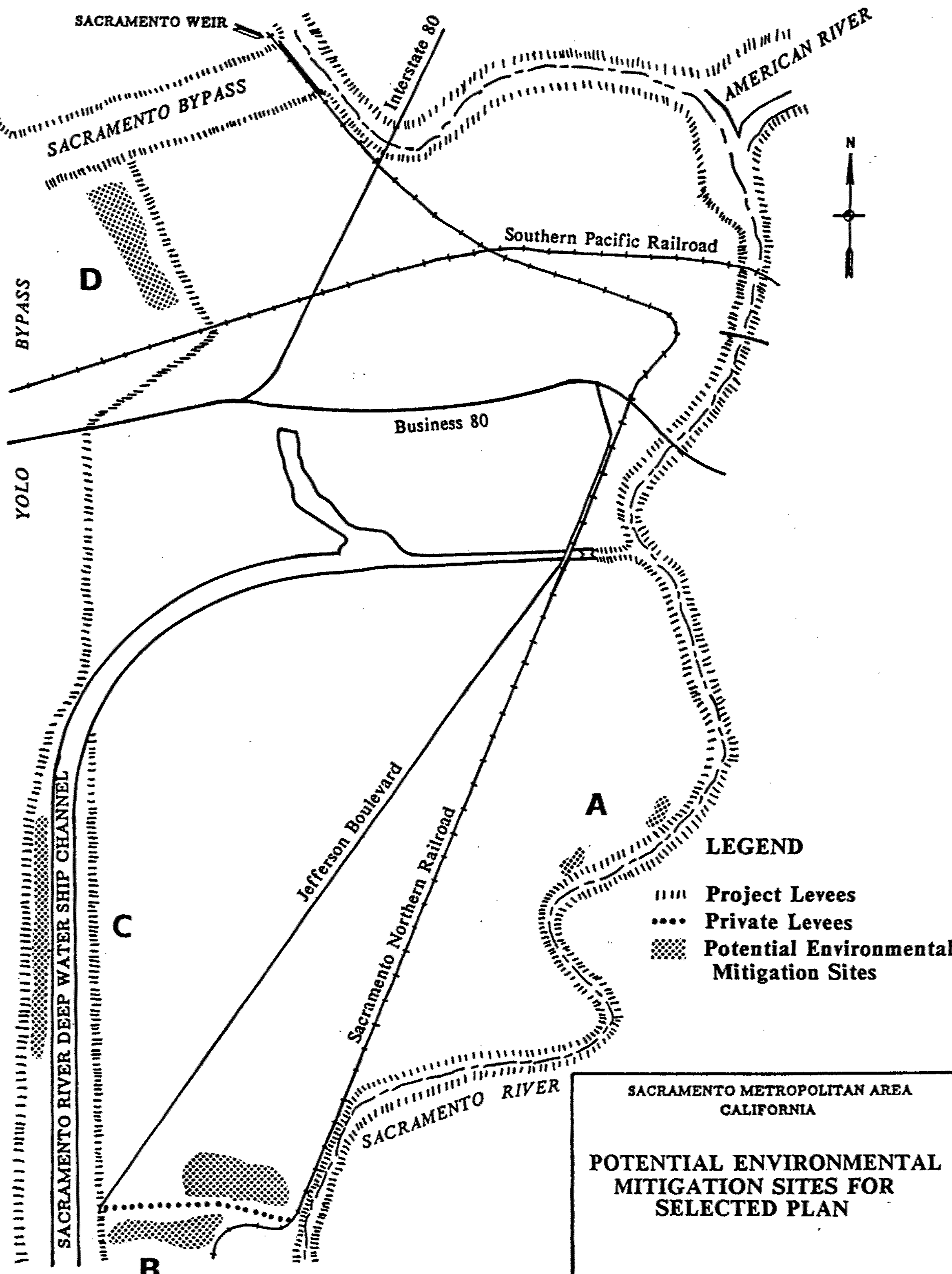
SACRAMENTO DISTRICT, CORPS OF ENGINEERS



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

PROJECT FEATURES FOR 100-YEAR, 200-YEAR AND 400-YEAR ALTERNATIVES

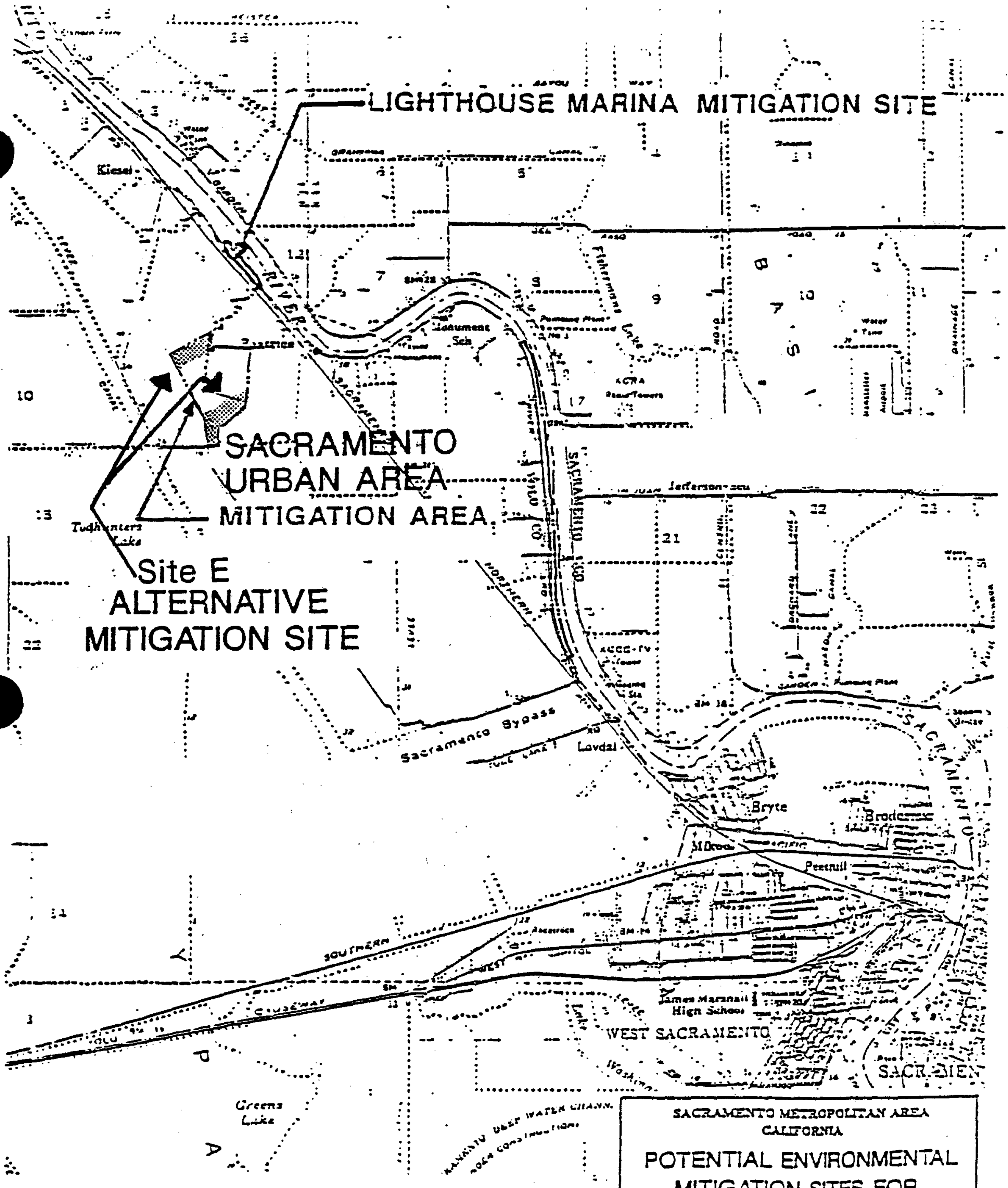
SACRAMENTO DISTRICT, CORPS OF ENGINEERS



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

POTENTIAL ENVIRONMENTAL MITIGATION SITES FOR SELECTED PLAN

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

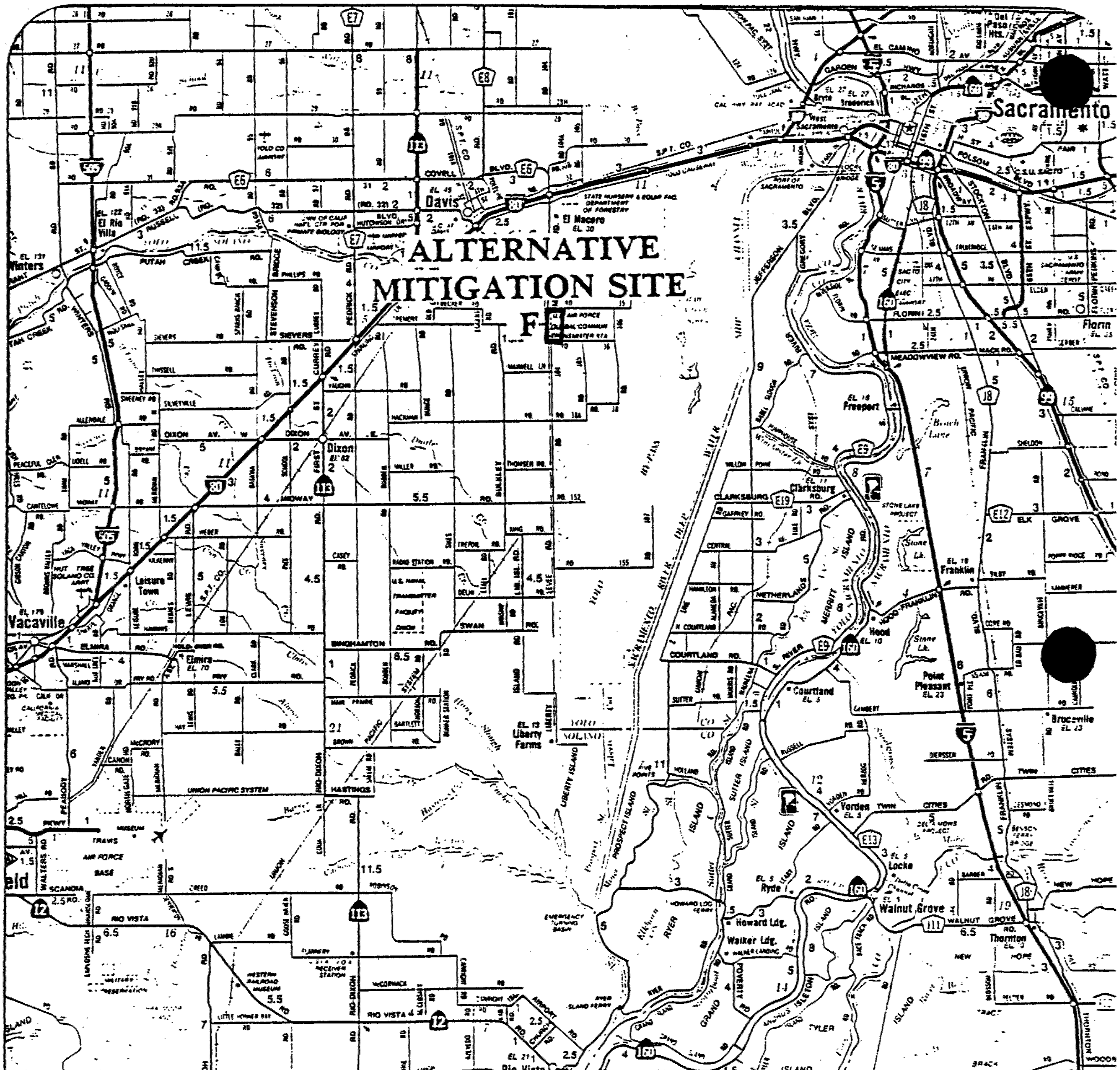


SACRAMENTO METROPOLITAN AREA
CALIFORNIA

POTENTIAL ENVIRONMENTAL
MITIGATION SITES FOR
SELECTED PLAN

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1992

PLATE 12A

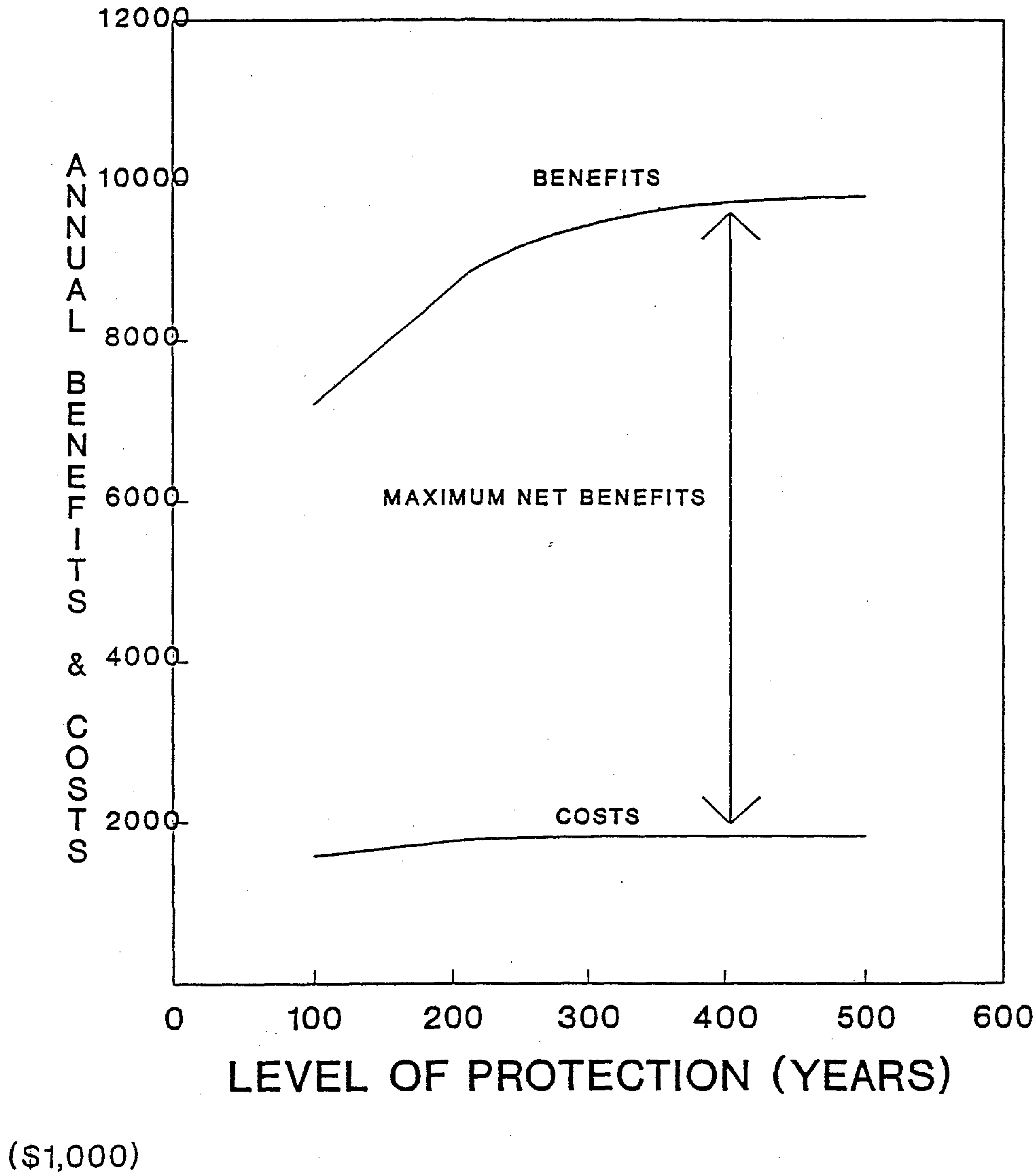


SACRAMENTO METROPOLITAN AREA
CALIFORNIA

POTENTIAL ENVIRONMENTAL MITIGATION SITES FOR SELECTED PLAN

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

PLATE 12B



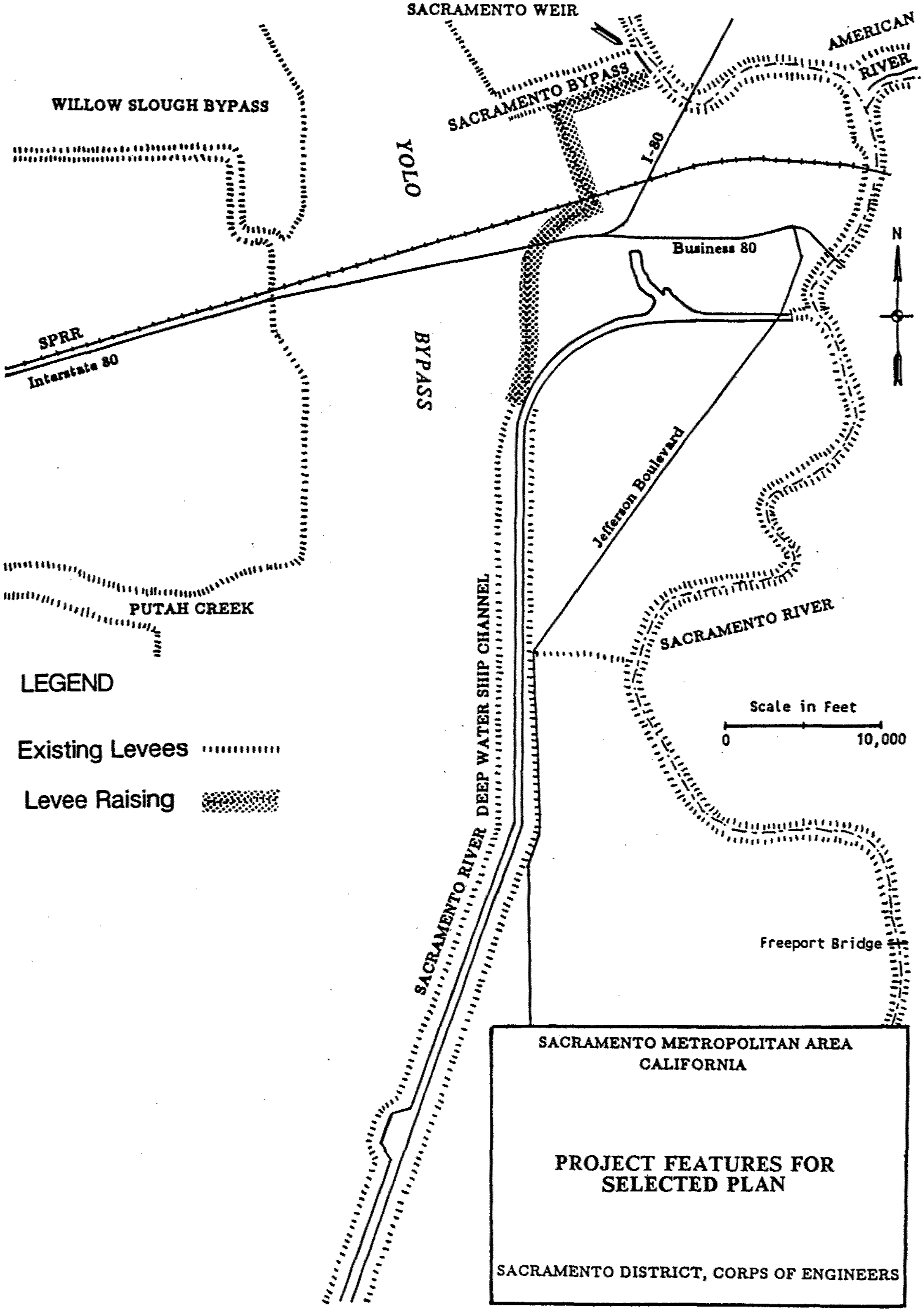
- OCTOBER 1991 PRICE LEVELS
- 100-YEAR PROJECT LIFE AND 8-3/4 PERCENT DISCOUNT RATE

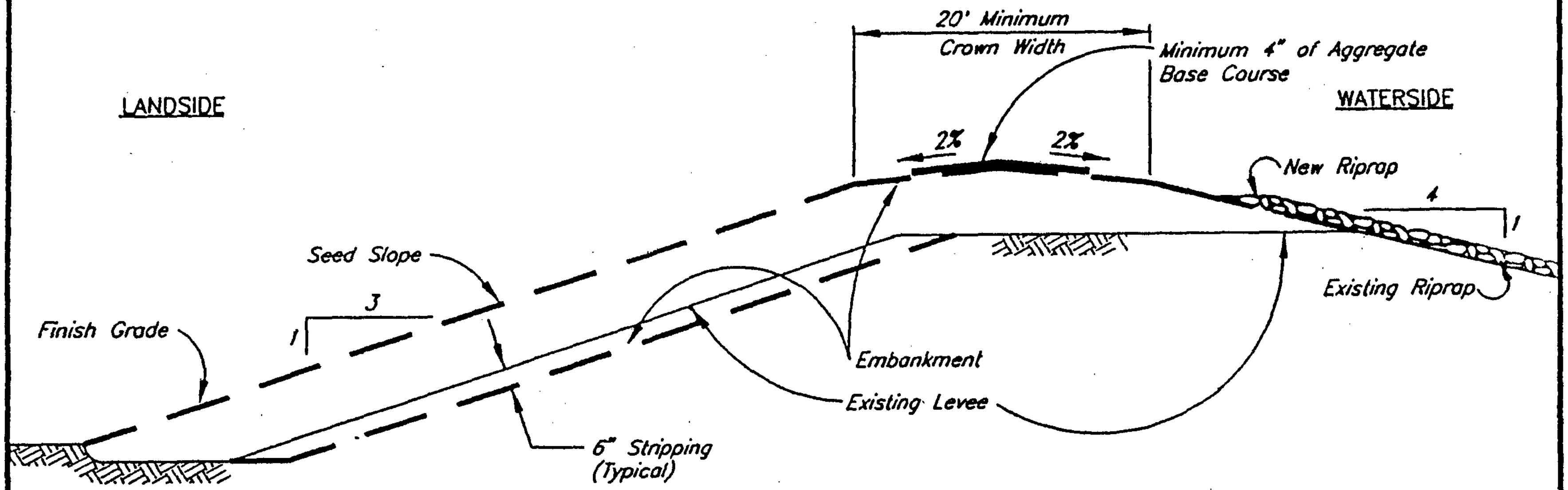
SACRAMENTO METROPOLITAN AREA
CALIFORNIA

PLAN OPTIMIZATION
BENEFITS AND COSTS
VS.
LEVEL OF FLOOD PROTECTION

SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SEPTEMBER 1991

PLATE 13


SACRAMENTO WEIR
AMERICAN RIVER
WILLOW SLOUGH BYPASS
SACRAMENTO BYPASS
YOLO BYPASS
I-80
Business 80
SPRR
Interstate 80
N
Jefferson Boulevard
PUTAH CREEK
DEEP WATER SHIP CHANNEL
SACRAMENTO RIVER
LEGEND
Existing Levees
Levee Raising
Scale in Feet
0
10,000
Freeport Bridge
SACRAMENTO METROPOLITAN AREA
CALIFORNIA
PROJECT FEATURES FOR SELECTED PLAN
SACRAMENTO DISTRICT, CORPS OF ENGINEERS



STEP 1: Strip 6" (waste material).

STEP 2: Remove material, if necessary, from Landside slope so that fill can be placed on a minimum 8-foot wide bench (if satisfactory material is removed, it may be used for embankment fill).

STEP 3: Place embankment material to lines and grades indicated. Materials shall be compacted to a minimum 95% of maximum density determined by ASTM D 698 at ±3% of optimum moisture content.

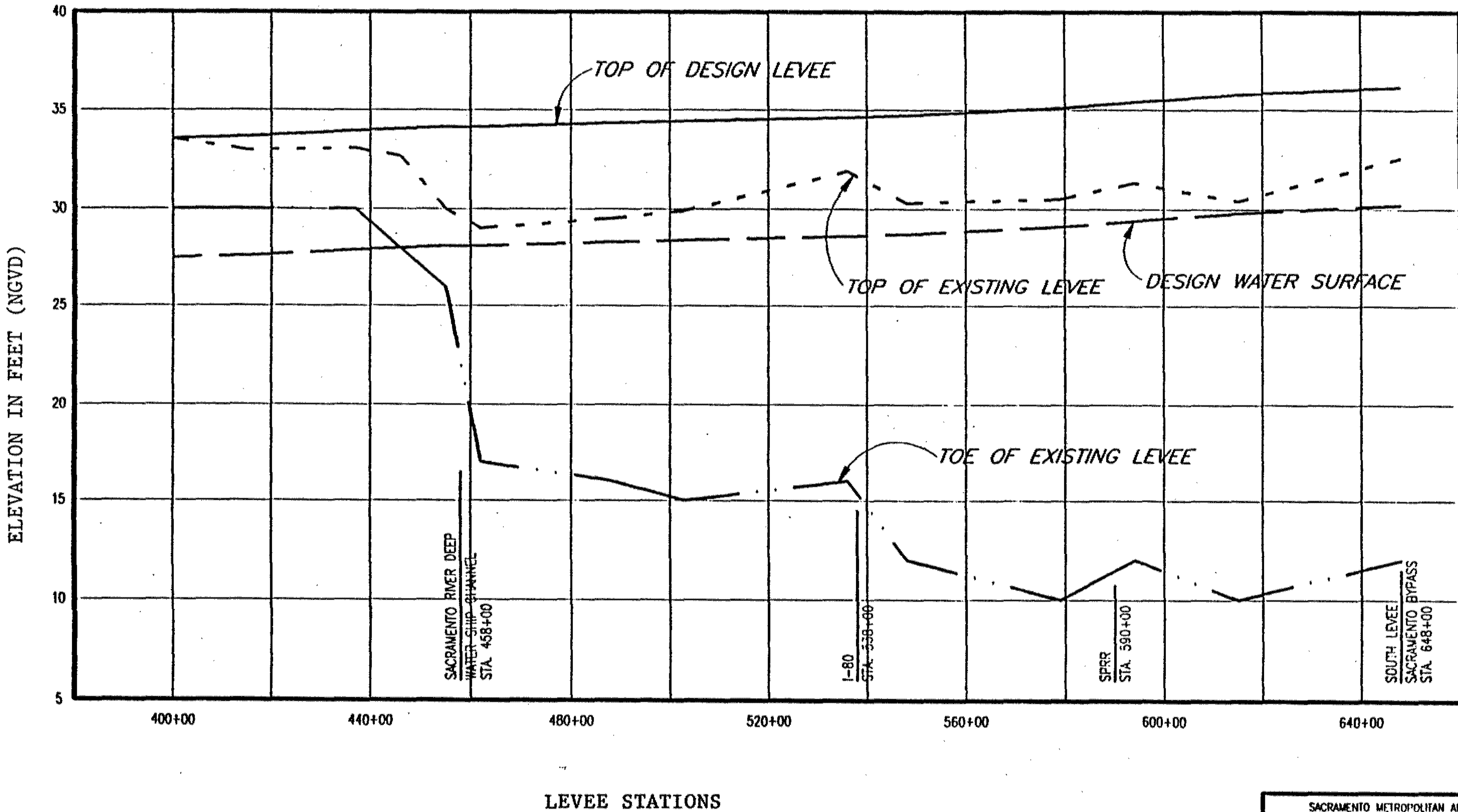
STEP 4: Place a minimum of 4 inches of aggregate base coursc for a 12-foot wide patrol road. Aggregate shall be compacted to a minimum of 100% of maximum density determined by ASTM D 698 at ±3% of optimum moisture content (crown width must be a minimum of 20 feet when construction is completed).

STEP 5: Place 12 inches of Riprap on new Waterside Slope.

STEP 6: Seed and establish grasses on new slopes, not ripraped, for erosion protection.

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

TYPICAL
FILL
LANDSIDE

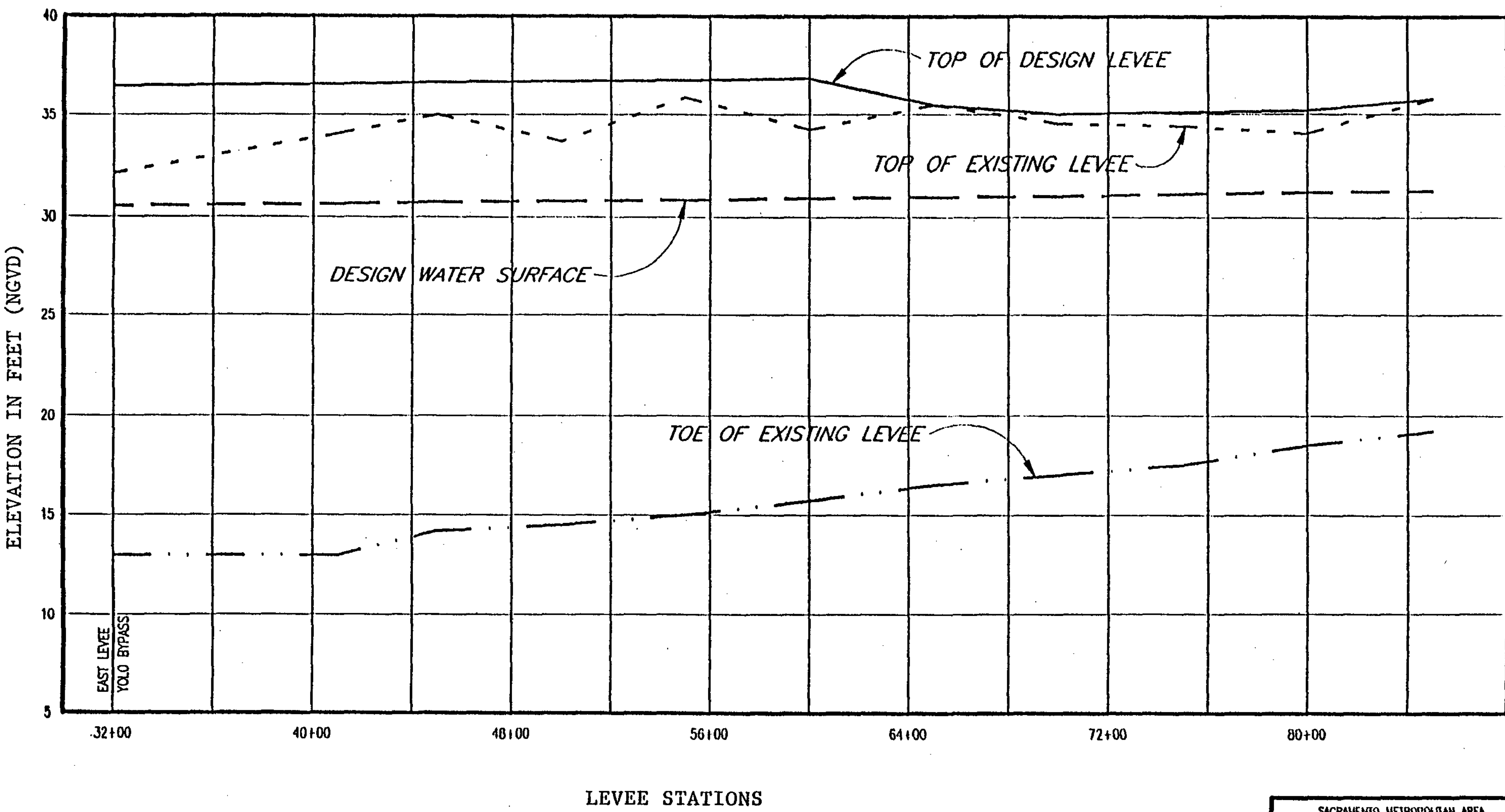


SACRAMENTO METROPOLITAN AREA
CALIFORNIA

LEVEE CROWN AND
WATER SURFACE PROFILES
YOLO BYPASS – EAST LEVEE
SELECTED PLAN

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

PLATE 16

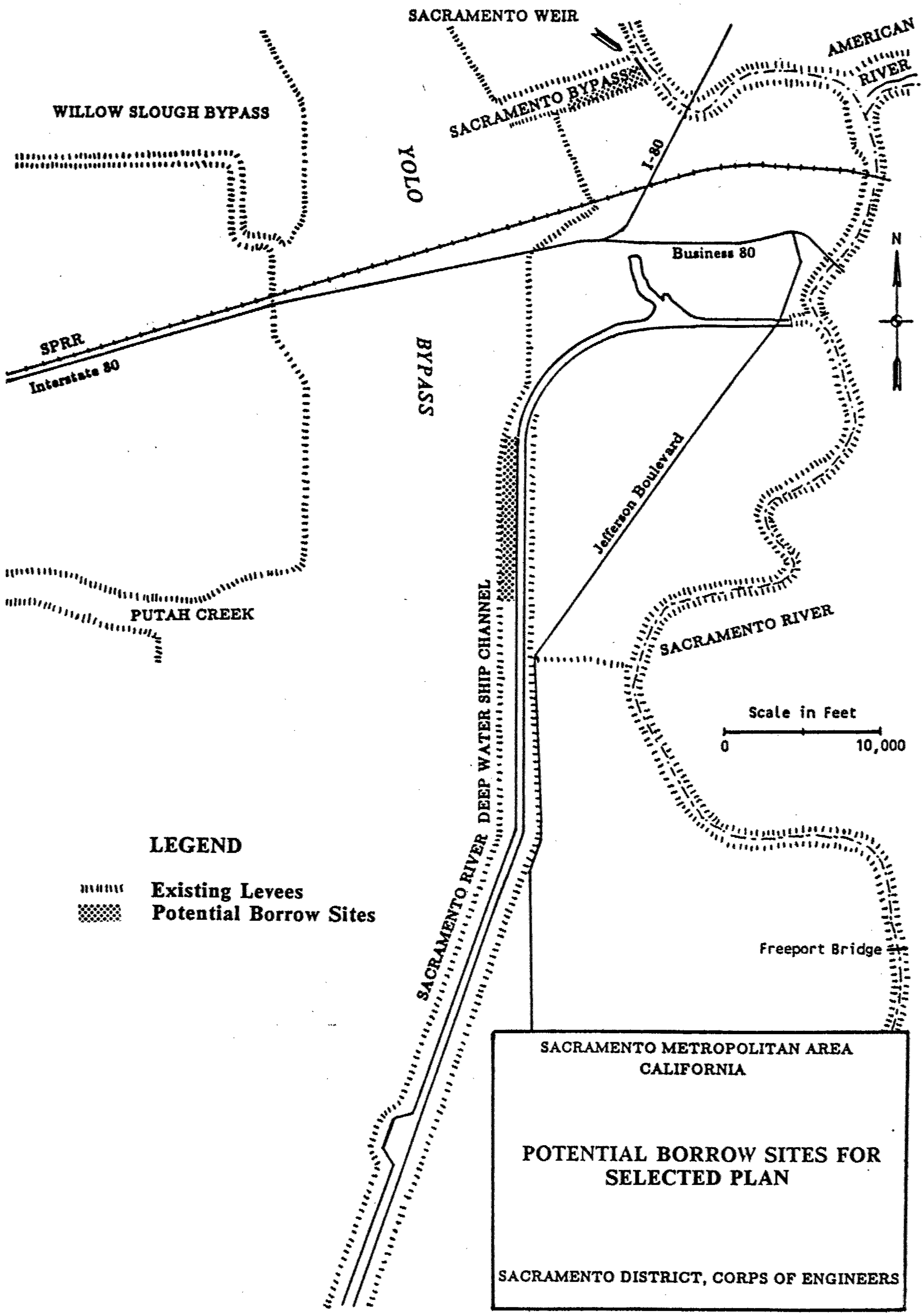


SACRAMENTO METROPOLITAN AREA
CALIFORNIA

LEVEE CROWN AND
WATER SURFACE PROFILES
SACRAMENTO BYPASS – SOUTH LEVEE
SELECTED PLAN

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

PLATE 17


SACRAMENTO WEIR
AMERICAN RIVER
WILLOW SLOUGH BYPASS
SACRAMENTO BYPASS
YOLO BYPASS
I-80
Business 80
N
SPRR
Interstate 80
Jefferson Boulevard
PUTAH CREEK
SACRAMENTO RIVER
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
Scale in Feet
0
10,000
LEGEND
Existing Levees
Potential Borrow Sites
Freeport Bridge
SACRAMENTO METROPOLITAN AREA
CALIFORNIA
POTENTIAL BORROW SITES FOR SELECTED PLAN
SACRAMENTO DISTRICT, CORPS OF ENGINEERS

SACRAMENTO METROPOLITAN AREA, CALIFORNIA

FEASIBILITY REPORT

APPENDIX A

ECONOMICS APPENDIX

Basis of Economic Analysis
Sacramento Metropolitan Area, California
(July 1991)

Introduction

The purpose of this section is to describe flood damage data and procedures used in computing future annual flood damages for without and with project conditions. This analysis is based upon a 100 year project life (1998-2098), October 1991 price levels and an 8 3/4 percent interest rate.

Without Project Conditions

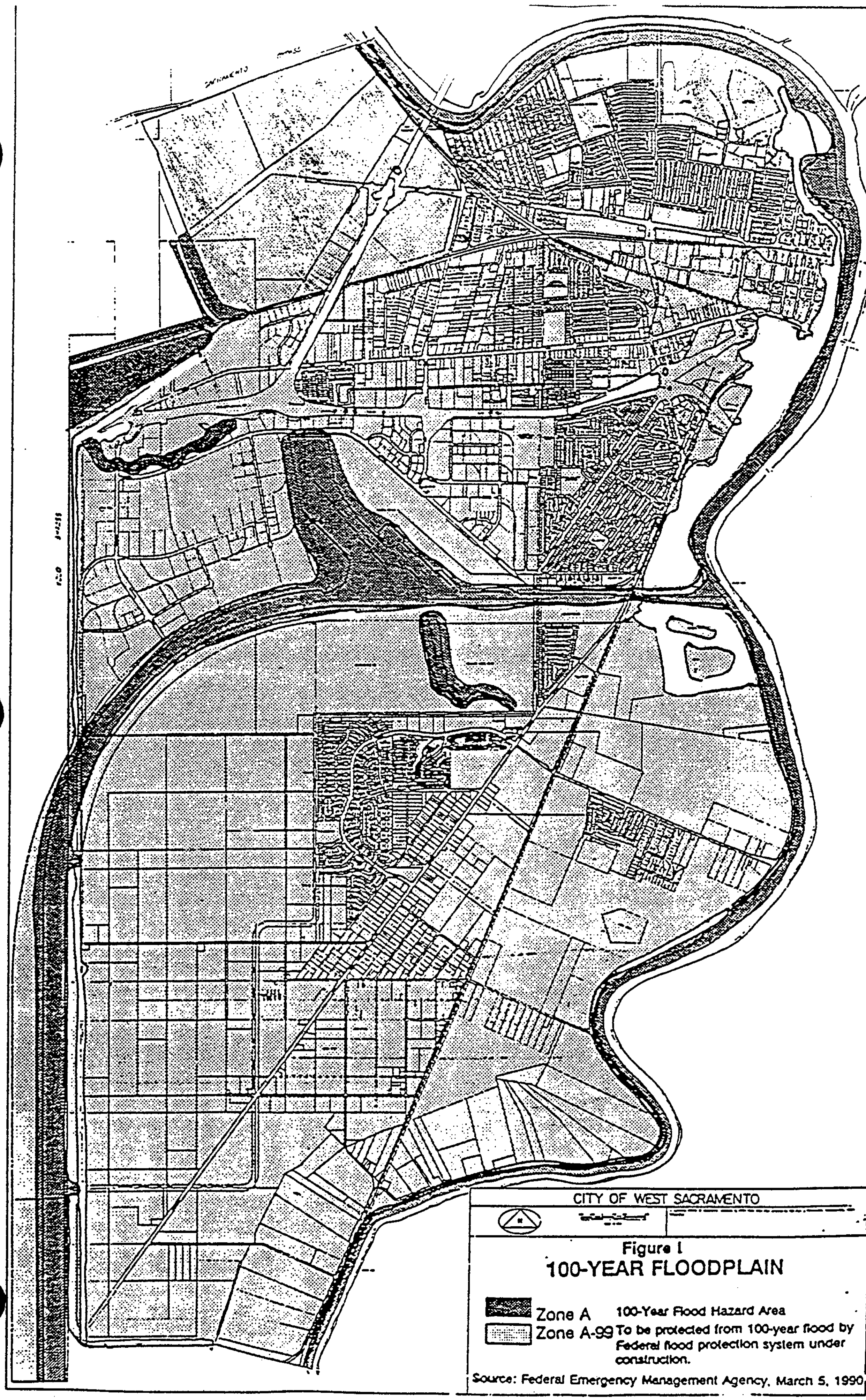
As a result of the record flood stages experienced during February 1986 and other recent high flood stage events, the Sacramento District Corps of Engineers recently reevaluated the current level of flood protection in West Sacramento. The District concluded that the levees along the Sacramento River and Yolo Bypass currently do not provide protection from a 100-year flood event. The Federal Emergency Management Agency (FEMA) revised the City's Flood Insurance Rate Maps (FIRM) and adopted the new maps in March 1990 as shown in Figure 1. In the revised FIRM, nearly all of the city is designated within the 100 year flood plain as an A-99 zone. This designation is normally used for areas where a Federal Flood Protection System is under construction. The A-99 zoning will end in 1992 if the City of West Sacramento cannot prove that adequate progress has been made in providing a 100-year level of flood protection. At that time, the area would be re-mapped in accordance with whatever flood protection was in existence and new flood hazard maps would be issued.

The assumption for the without project condition is that the A-99 zoning will be terminated in 1992. At that time, the City will continue to participate in the National Flood Insurance Program and will ensure that their local regulations are in full compliance with standards adopted by FEMA. Some of the local flood-related regulations currently outlined in the City of West Sacramento General Plan-Policy Document (1990) include the following:

(1) New residential development, including mobile homes, shall be constructed so that the lowest floor is at least 12 inches above the 100 year level for storm damage.

(2) Non-residential development shall be anchored and flood proofed to prevent damage from the 100 year flood or, alternatively, elevated to at least 12 inches above the 100-year flood level.

(3) Existing development shall comply with policies #1 and #2 when improvements are made costing at least 50 percent of the estimated current market value of the structure before improvements.


CITY OF WEST SACRAMENTO
Figure I
100-YEAR FLOODPLAIN
Zone A 100-Year Flood Hazard Area
Zone A-99 To be protected from 100-year flood by Federal flood protection system under construction.
Source: Federal Emergency Management Agency, March 5, 1990

(4) New development shall be designed to prevent the diversion of floodwater onto neighboring parcels.

Compliance with the regulations creates a problem when considering the extremely deep depths of flooding (see Figure 2) and the lack of practical flood proofing measures available for the study area. Local city planners were asked what effect this might have on future development and they indicated three possible approaches that the City might use to solve the problem.

(1) A deepening of the Yolo Bypass.

(2) Creation of an internal levee system that would result in a series of islands. Levees would be built initially around existing pockets of development.

(3) Work would be done on improving the existing levees to increase the level of protection (similar to Corps proposal).

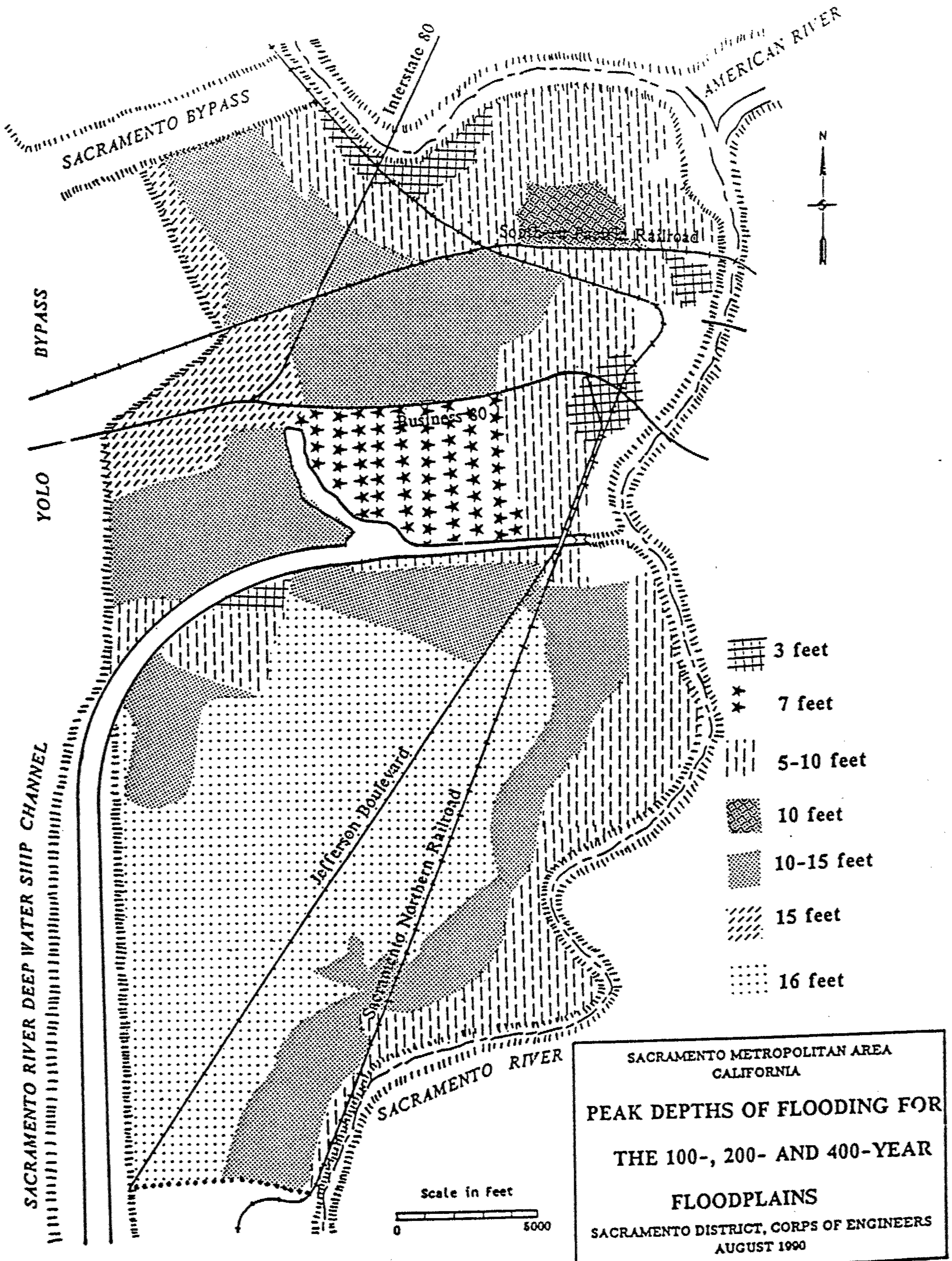
The first two approaches were considered to be costly with the second being described as a fiscal disaster. This is because homes would have to be removed in order to implement the project. The third approach was determined to be the most likely one the City would undertake. ER 1105-2-100 (28 December 1990), Section III, 4-11 (8) states "If the local interests are willing to build a given flood control project, but only if the Corps doesn't do it, assume no project as without project condition." This economic analysis assumes that there will be no growth after 1992 under without project conditions.

1. <u>Value of Damageable Property</u>

There are approximately 12,000 acres in the study area and the extent of existing development can be seen in Figure 3. An inventory of properties was undertaken in order to establish the value of damageable properties within the flood plain. By means of field surveys, aerial photography, analysis of other available data (e.g. zoning map), the number and size (square footage) of physical units in the flood plain were determined for each of the following categories: residential (single family, multiple, mobile homes), commercial, industrial, public and semi-public, and farm buildings. The data was compiled by depth of flooding and structure foundation height (first floor elevation).

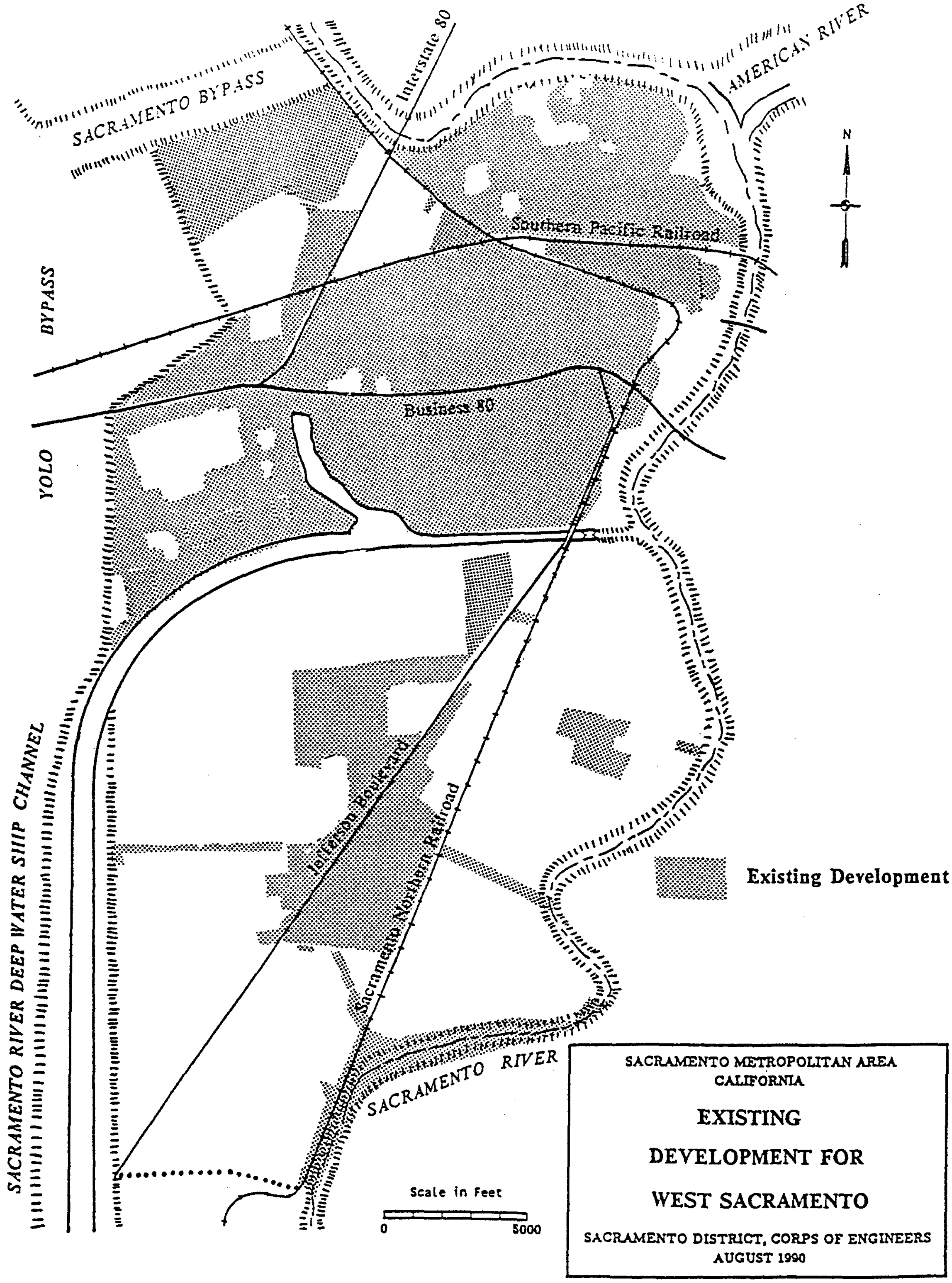
Once the square footage was determined, the next step was to assign values to each property. Appraisal handbooks (published by Marshall and Swift) were used to establish replacement costs. Then as suggested in ER 1105-2-100, a depreciation value was determined. The depreciation which accounts for deterioration occurring prior to flooding was established through discussions with real estate appraisers knowledgeable in properties in the study area. A summary of the data by foundation height and depth of flooding is provided in Table 1.

Although depreciation values have been used in our analysis, market values also had to be considered because of the local flood plain regulation mentioned previously. This regulation requires structures to be flood proofed whenever improvements are



SACRAMENTO BYPASS
AMERICAN RIVER
Interstate 80
Railroad
Business 80
YOLO BYPASS
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
Jefferson Boulevard
Sacramento Northern Railroad
SACRAMENTO RIVER
N
3 feet
7 feet
5-10 feet
10 feet
10-15 feet
15 feet
16 feet
Scale in Feet
0
5000
SACRAMENTO METROPOLITAN AREA
CALIFORNIA
PEAK DEPTHS OF FLOODING FOR
THE 100-, 200- AND 400-YEAR
FLOODPLAINS
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
AUGUST 1990

FIGURE 2



SACRAMENTO BYPASS
Interstate 80
AMERICAN RIVER
N
Southern Pacific Railroad
YOLO BYPASS
Business 80
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
Jefferson Boulevard
Sacramento Northern Railroad
Existing Development
SACRAMENTO RIVER
Scale in Feet
0
5000
SACRAMENTO METROPOLITAN AREA
CALIFORNIA
EXISTING
DEVELOPMENT FOR
WEST SACRAMENTO
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
AUGUST 1990

FIGURE 3

TABLE 1
LAND USE INVENTORY

SQ.FEET	LAND USE	FOUND	#STR	STRUCT$	CONTENT$	DEPR$STR	DEPR$CON	DEPTH
274,000	1	0.5	266	11,694,500	5,847,300	9,387,100	4,693,500	7.5
448,000	1	0.5	448	17,838,900	8,919,500	13,264,800	6,632,400	10
206,000	1	1	206	8,202,700	4,101,400	6,099,500	3,049,700	3
2,442,500	1	1	1,779	83,694,800	41,847,400	61,740,000	30,870,000	7.5
272,200	1	1	275	10,835,900	5,417,900	8,085,300	4,042,600	10
681,250	1	1	670	28,077,500	14,038,700	21,489,000	10,744,500	12.5
82,800	1	1	69	3,311,100	1,655,600	2,465,700	1,232,900	15
353,400	1	1	310	19,940,100	9,970,100	17,091,500	8,545,800	16
62,700	1	1.5	66	3,504,100	1,752,000	3,032,400	1,516,200	3
106,900	1	1.5	74	5,984,100	2,992,000	5,143,800	2,571,900	7
1,583,800	1	1.5	1,328	88,599,300	44,299,700	76,366,700	38,183,400	7.5
190,750	1	1.5	218	10,683,700	5,341,900	9,125,700	4,562,800	12.5
621,300	1	1.5	545	35,056,000	17,528,000	30,048,000	15,024,000	16
7,325,600			*6,254*	*327,422,700*	*163,711,500*	*263,339,500*	*131,669,700*	
35,320	2	0.5	61	1,435,500	717,700	1,076,400	538,200	3
159,730	2	0.5	243	6,880,400	3,440,200	5,060,900	2,530,400	7.5
16,010	2	0.5	34	653,800	326,900	490,400	245,200	10
214,710	2	0.5	158	5,435,900	2,717,900	4,263,900	2,131,900	12.5
470,400	2	0.5	392	26,415,300	13,207,700	24,009,800	12,004,900	16
60,200	2	1	43	3,380,500	1,690,300	2,897,600	1,448,800	7.5
169,400	2	1	121	9,512,700	4,756,300	8,153,700	4,076,900	12.5
14,000	2	1	10	786,200	393,100	673,900	336,900	16
1,139,770			*1,062*	*54,500,300*	*27,250,100*	*46,626,600*	*23,313,200*	
2,000	3	0.5	2	79,600	39,800	59,200	29,600	7.5
138,000	3	1	138	5,495,000	2,747,500	4,086,000	2,043,000	3
36,000	3	1	36	1,433,500	716,700	1,065,900	533,000	7.5
176,000			*176*	*7,008,100*	*3,504,000*	*5,211,100*	*2,605,600*	
17,930	4	0.5	36	970,100	485,100	823,700	411,900	3
470,660	4	0.5	592	19,307,700	9,653,800	14,515,500	7,257,700	7.5
172,040	4	0.5	227	7,026,100	3,513,100	5,269,600	2,634,800	10
605,880	4	0.5	715	31,058,900	15,529,400	24,419,100	12,209,600	12.5
158,400	4	0.5	132	8,625,400	4,312,700	7,277,700	3,638,800	16
1,424,910			*1,702*	*66,988,200*	*33,494,100*	*52,305,600*	*26,152,800*	

TABLE 1
(Continued)

145,950	5	0.5	16	6,559,600	7,023,800	4,596,400	4,920,300	3
321,180	5	0.5	21	15,579,000	17,065,300	11,263,500	12,570,400	7
943,200	5	0.5	113	40,066,900	43,743,700	28,125,000	30,815,700	7.5
94,550	5	0.5	19	1,809,900	2,506,000	1,179,500	1,637,700	10
961,400	5	0.5	84	29,375,700	32,167,900	20,267,700	22,174,800	12.5
177,050	5	0.5	16	5,557,200	5,990,100	3,952,800	4,302,900	15
57,550	5	0.5	10	1,597,400	1,787,000	103,300	1,131,800	16
53,550	5	2	50	1,464,400	0	1,464,400	0	12.5
2,754,430			*329*	*102,010,100*	*110,283,800*	*70,952,600*	*77,553,600*	
8,000	6	0.5	1	289,000	315,000	202,300	220,500	7.5
5,850	6	0.5	1	78,500	88,700	39,200	44,300	12.5
13,850			*2*	*367,500*	*403,700*	*241,500*	*264,800*	
145,600	7	0.5	15	2,316,500	2,634,500	1,298,800	1,474,800	3
2,699,900	7	0.5	78	105,491,300	103,441,500	89,846,000	85,867,400	7
349,950	7	0.5	20	33,010,400	11,501,400	30,706,800	8,889,200	7.5
332,550	7	0.5	38	4,555,900	5,168,500	2,278,000	2,584,200	10
2,703,030	7	0.5	126	60,280,500	68,734,300	40,310,500	46,002,200	12.5
1,089,000	7	0.5	50	24,812,400	27,730,200	18,437,000	20,705,100	15
36,850	7	3	3	684,500	773,500	342,300	386,800	7.5
8,000	7	3	1	107,300	121,300	53,700	60,600	10
74,850	7	3	5	1,480,700	1,673,200	817,800	924,100	12.5
49,600	7	4	2	1,129,400	839,600	713,300	587,700	7.5
4,200	7	4	1	56,300	63,700	18,800	21,200	12.5
7,493,530			*339*	*233,925,200*	*222,681,700*	*184,823,000*	*167,503,300*	
32,180	8	0.5	7	1,142,100	439,800	871,500	316,900	3
230,000	8	0.5	13	7,579,900	5,035,600	5,900,900	3,918,600	7
459,470	8	0.5	102	51,300,000	21,549,200	43,259,700	18,516,000	7.5
37,100	8	0.5	3	1,202,800	1,242,800	854,900	873,100	10
61,830	8	0.5	12	2,730,200	666,600	2,320,600	715,400	12.5
4,800	8	0.5	3	118,900	134,300	83,200	94,000	15
117,250	8	0.5	10	5,018,200	1,296,900	4,195,300	1,071,700	16
11,000	8	1	1	533,500	602,900	373,500	422,000	7.5
953,630			*151*	*69,625,600*	*30,968,100*	*57,859,600*	*25,927,700*	
338,100	9	2	421	8,792,400	4,396,200	6,340,600	3,170,300	7.5
183,750	9	2	195	4,916,400	2,458,200	4,164,100	2,082,100	10

TABLE 1
(Continued)

338,630	9	2	574	8,202,800	4,101,400	4,246,700	2,123,300	12.5
250,950	9	2	239	6,825,800	3,412,900	5,919,600	2,959,800	15
1,111,430			*1,429*	*28,737,400*	*14,368,700*	*20,671,000*	*10,335,500*	
5,400	10	0.5	2	199,700	167,700	139,800	117,400	3
249,700	10	0.5	13	9,321,700	9,399,100	6,931,600	6,917,900	7.5
36,400	10	0.5	1	1,164,500	978,200	815,200	684,700	10
8,600	10	0.5	3	317,900	284,100	222,500	198,900	12.5
300,100			*19*	*11,003,800*	*10,829,100*	*8,109,100*	*7,918,900*	
416,800	11	0.5	5	10,323,300	11,665,300	7,226,300	8,165,700	7
583,200	11	0.5	4	14,444,700	16,322,500	10,111,300	11,425,800	12.5
213,300	11	0.5	2	5,283,000	5,969,800	3,698,100	4,178,900	15
217,600	11	3	1	5,614,100	6,343,900	3,929,900	4,440,700	12.5
1,430,900			*12*	*35,665,100*	*40,301,500*	*24,965,600*	*28,211,100*	
68,400	12	0.5	51	628,500	710,200	314,300	355,100	7.5
36,330	12	0.5	35	333,800	377,200	166,900	188,600	12.5
222,300	12	0.5	196	2,042,700	2,308,300	1,021,400	1,117,700	16
327,030			*282*	*3,005,000*	*3,395,700*	*1,502,600*	*1,661,400*	
6,000	13	0.5	1	291,000	328,900	203,700	230,200	7.5
6,000			*1*	*291,000*	*328,900*	*203,700*	*230,200*	

TABLE 1
(CONTINUED)

LAND USE DESIGNATIONS

1. SINGLE FAMILY RESIDENTIAL (1-STORY)
2. MULTIPLE FAMILY RESIDENTIAL (1-STORY) DUPLEXES/ APARTMENT
3. MULTIPLE FAMILY RESIDENTIAL (2-STORY) 2 UNITS/ STRUCTURE
4. MULTIPLE FAMILY RESIDENTIAL (2-STORY) APARTMENTS
5. COMMERCIAL (1-STORY)
6. COMMERCIAL (2-STORY)
7. INDUSTRIAL
8. PUBLIC (1-STORY)
9. MOBILE HOMES
10. COMMERCIAL (FOOD RELATED)
11. INDUSTRIAL (FOOD RELATED)
12. SHEDS
13. PUBLIC (2-STORY)

made which cost at least 50 percent of the estimated current market value of the structures before the improvements are undertaken. Discussion with a FEMA official indicates that this regulation will be enforced by their agency and homes along the Russian River in Sonoma County, California were cited as an example.

The inventory shown in Table 1 is a compilation of all the structures in the flood plain and includes those affected by the 50 percent requirement. Table 2 is a summary of the information presented in Table 1 but also has additional columns for comparison purposes to show how many structures are affected by FEMA's requirement and their value. The number of impacted structures depends upon the depth of flooding, the depth-damage relationship for that land use, and the current market value. Unlike some of the other land use categories (e.g. industrial), the depreciated values for residential structures do not reflect current market values. A residential property appraiser indicated that the buyers feel that they are under pressure to buy homes now because they fear that they will be priced out of the housing market if they wait. This is the reason why very few of the residential structures are affected by FEMA's requirement (see Table 2) even when the depths of flooding are 15'-16'. The depth-damage relationships which were an important factor in evaluating the impact of this requirement will be addressed later in the Flood Damages section.

The damageable property in the flood plain is worth approximately $1.2 billion. This excludes lands, roads, utilities, and bridges. Figure 4 indicates what each land use category contributes in terms of percentage to the overall value. This figure indicates that single family residential (31.9%) and industrial (32.7%) are the largest land use categories. The commercial and industrial values reflect not only the structure value but also includes the inventory on hand and the values of the fixtures and equipment.

2. <u>Flood Damage</u>

Once the inventory was completed (Table 1) and depths of flooding and values of damageable property were computed, the next step was to determine the amount of flood damages associated with each land use category.

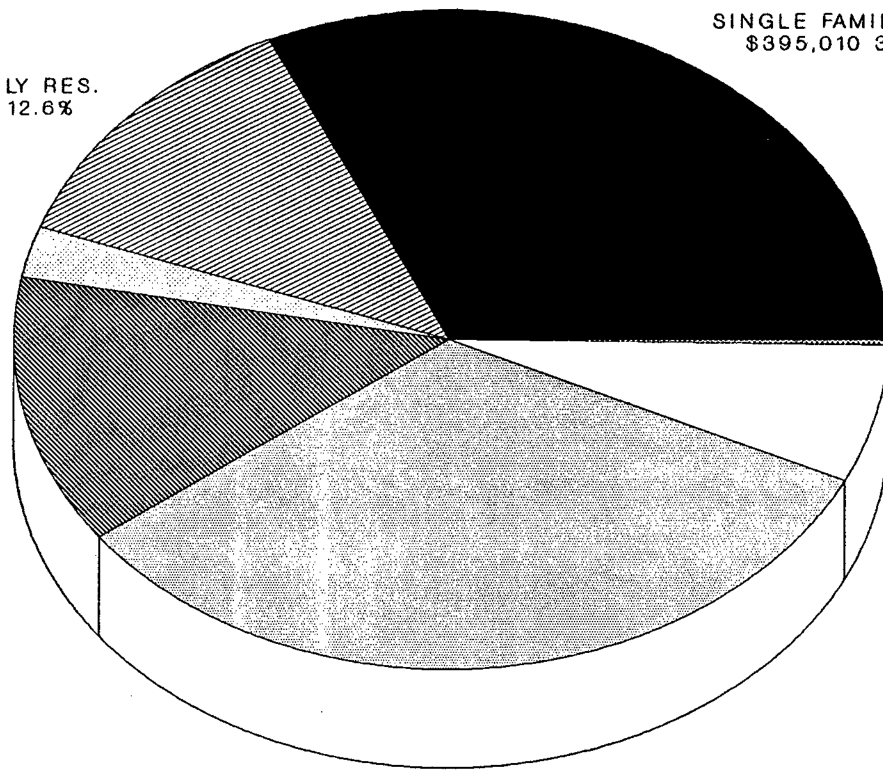
The principal types of flood damages considered in this analysis are those physical damages that are caused by inundation. Physical damages include damages to, or loss of, buildings and their contents, which include furnishings, equipment and fixtures, raw materials, goods in process, and finished products awaiting distribution. Other physical losses considered are damages to lot improvements, such as clean up, as well as damages to roads, bridges, and utilities.

Physical losses incurred within the defined study flood plain were estimated for the following land use categories: residential, including single family, multiple and mobile homes; commercial; industrial; public and semi-public; and agricultural. Monetary losses relating to residential include damages to structures, contents and yard areas. Commercial and industrial losses include damage to structures, inventories,

TABLE 2
DEPRECIATED VALUE OF DAMAGEABLE PROPERTY
1990 CONDITIONS
OCTOBER 1991 PRICE LEVELS (THOUSANDS)

LAND USE	VALUE OF PROPERTY	PORTION AFFECTED BY FEMA 50%	NUMBER OF UNITS	PORTION AFFECTED BY FEMA 50%
SINGLE FAM. RES. STR.	$263,340	$0	6,254	0
SINGLE FAM. RES. CONT.	131,670	0	"	"
MULTI-FAMILY RES. STR.	104,143	9,704	2,940	14[illegible]
MULTI-FAMILY RES. CONT.	52,072	4,852	"	"
MOBILE HOMES STR.	20,671	17,613	1,429	758
MOBILE HOMES CONT.	10,336	8,807	"	"
COMMERCIAL	165,041	54,749	350	163
INDUSTRIAL	405,503	151,619	351	181
PUBLIC	84,221	6,350	152	13
FARM BUILDINGS	3,164	0	282	0
TOTAL:	$1,240,161	$253,694	11,758	1,259

FIGURE 4
DAMAGEABLE PROPERTY BY LAND USE
(PERCENTAGES)



fixtures and equipment, and parking areas. Public facilities losses include damages to public buildings (structure and content) as well as damages to roads, bridges, railroads, municipal water systems, and utilities. Damages to semi-public property include structure, content, and lot damage to churches and recreation clubs. Agricultural damages, the remaining category, include damages to farm buildings (barns, sheds) as well as crop and non-crop losses.

Additional costs are incurred during flood emergencies for evacuation and reoccupation, flood fighting, disaster relief, and extra duty for police, fire and military units. These costs are called emergency costs in our analysis. Intangible damages, such as loss of life, impairment of health and living conditions, and other conditions that cannot be evaluated in monetary terms, have not been included in the damage analysis.

The data collected in Table 1 was converted into damages through the use of depth-damage relationships. These relationships describe the probable damages that would occur under different depths of flooding as a percentage of the total value of damageable property (see Table 3). The depths of flooding are shown in Figure 2 and are essentially the same for the 100, 200, and 400 year events. The depth-damage curves used in this analysis were based primarily upon the 1988 FEMA curves and curves from a Tennessee Valley Authority (TVA) study prepared for the Department of Housing and Urban Development in December 1969.

These established curves were used because they are based upon a large number of flood damage claims (FEMA) and surveyed establishments. TVA surveyed 300 commercial establishments for their study. The methodology used in this study was to take the interviews and flood damage survey data from District studies, a much smaller sample, and validate or invalidate the use of the established curves.

The 1988 FEMA curves were used for residential properties in the flood plain. These national depth-damage relationships were determined to be appropriate for use in the study area based upon information gathered on another District study (Dry Creek, California) within close proximity of the City of West Sacramento. The residential structures in both areas are comparable in terms of the type of construction. The Dry Creek area experienced a flood in 1986, and a residential damage survey was done following that event. Flood damage information had been collected in a detailed manner, and the address of each house affected by the flood was noted on the survey sheet. This information was then combined with other data developed in conjunction with the District's Dry Creek study including property values, flood plains, depths of flooding and the frequency of the 1986 event to determine the actual depth versus percent damage relationships. These were then compared to the 1970 Federal Insurance Administration and 1988 FEMA curves. The comparison indicated that the 1988 FEMA residential curves appeared to be more appropriate for use in this study. The curves in this study were not only adjusted for variations in foundation elevations but also for the number of stories (one vs. two-story).

TABLE 3
DEPTH-DAMAGE RELATIONSHIPS

DEPTH OF FLOOD (FT)	RES.STR. (2)	RES.CONT. (2)	RES.STR. (3)	RES.CONT. (3)	RES.STR. (4)	RES.CONT. (4)	MULT.RES. STR.(5)	MULT.RES. CONT.(5)	MULT.RES. STR.(6)	MULT.RES. CONT.(6)	M.H. STR. (9)	M.H.CONT. (9)	IND.STR. (1)	IND.CONT. (1)	COMM.STR. (1)	COMM.CONT (7)	COMM.STR. (10)	COMM.CONT (8)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.5	7.7	0	3.8	0	2.6	0	5.1	0	2.6	0	0	0	5	0	5	0	4.5	0
0.6	8.3	11.3	4.6	0	3.1	0	5.5	7.4	3.1	0	0	0	5.2	2.4	5.2	0.8	5.2	0.8
1	10.6	17.2	7.7	0	5.1	0	7	8.8	5.1	0	0	0	7	12	7	4	7	4
1.1	11.2	18.4	8.3	11.3	5.6	0	7.4	9.1	5.5	7.4	0	0	7.2	14.4	7.2	5.4	7.2	5.4
1.5	13.5	23.1	10.6	16.5	7.7	0	9	10.5	7	8.8	0	0	9	24	9	11	8.1	11
1.6	14.2	24	11.2	17.8	8.3	11.3	9.4	11.3	7.4	9.1	0	0	9.2	25.8	9.2	12.4	8.3	12.4
2	16.9	27.5	13.5	23.1	10.6	16.5	11	14.3	9	10.5	8	0	11	33.2	11	18	9.2	18
2.1	17.6	28.1	14.2	24	11.2	17.6	11.4	14.9	9.4	11.2	11.5	3.2	11.2	35	11.2	20.7	9.4	20.7
3	23.5	33.3	20.4	31.9	16.9	27.5	15.5	20.3	13	18	43	26.6	15.5	50.8	15.5	45	11.1	45
5	29.3	38.8	28.7	36.9	27.6	35.8	21	30.6	20	28.2	73	64.1	24	73.2	24	73	16.1	73
7.5	42.8	49.9	41.8	47.4	40.7	44.9	26	43.9	25	41.4	79.5	76.6	35.3	82.5	35.3	80	22	80
9	44.5	57.4	44	54.8	43.4	52.3	32	51.8	30	49.8	82	78.8	41.9	82.5	41.9	80	25	80
10	45.6	59.9	45	59.9	44.5	57.3	36	55.9	34	53.9	85	80.7	46.5	82.5	46.5	80	28	80
11	46.7	59.9	46.3	59.9	45.6	59.9	38	57.9	38	57.9	90	82.9	51	82.5	51	80	30	80
12.5	48.3	59.9	47.7	59.9	47.1	59.9	38	57.9	38	57.9	98	82.9	60	82.5	60	80	35.5	80
13	48.6	59.9	48.3	59.9	47.7	59.9	38	57.9	38	57.9	100	82.9	60	82.5	60	80	36.5	80
15	50	59.9	50	59.9	49.5	59.9	38	57.9	38	57.9	100	82.9	60	82.5	60	80	43.2	80
16	50	59.9	50	59.9	50	59.9	38	57.9	38	57.9	100	82.9	60	82.5	60	80	45.9	80
17	50	59.9	50	59.9	50	59.9	38	57.9	38	57.9	100	82.9	60	82.5	60	80	48	80

(1) TVA STUDY - 0.5' FOUNDATION 1-STORY
(2) FEMA CURVES 1988 - 0.5' FOUNDATION 1-STORY
(3) FEMA CURVES 1988 - 1.0' FOUNDATION 1-STORY
(4) FEMA CURVES 1988 - 1.5' FOUNDATION 1-STORY
(5) FEMA CURVES 1988 - 0.5' FOUNDATION 2-STORY
(6) FEMA CURVES 1988 - 1.0' FOUNDATION 2-STORY
(7) TVA STUDY - 0.5' FOUNDATION 1-STORY
(8) TVA STUDY - 0.5' FOUNDATION 2-STORY
(9) FEMA CURVES 1988 - 2.0' FOUNDATION
(10) TVA STUDY - 0.5' FOUNDATION 2-STORY

A comparison of various established depth-damage relationships for commercial and industrial properties also was undertaken to determine which would be the most appropriate curves for use in the study area. The 1988 FEMA curves and the 1969 TVA study curves were evaluated based upon information gathered for the District's Morrison Creek, California study. The structures in both the West Sacramento and Morrison Creek areas are comparable in the type of construction and the use and are located within close proximity of each other. Much of West Sacramento's commercial/industrial development in terms of value of damageable property is in older and newer warehousing so a large number of depth-damage relationships for structures would be inappropriate.

The types of contents inside the commercial and industrial properties required some initial screening before the comparison of depth-damage relationships took place. Food-related structures were identified during the field inventory and separated from the remaining ones. Information on them is shown in Table 1, and a different depth-damage curve was used than those shown in Table 3 because damages are 100 percent once water gets inside the structures irregardless of the depth. The health department would not allow the sales of these products for health and sanitary reasons.

The remaining structures were evaluated based upon interviews with individuals familiar with the contents of commercial/industrial warehousing and then compared to the 1988 FEMA and the 1969 TVA curves. The TVA study essentially says that their survey showed that businesses could be categorized into two groups and that their depth-damage curves are S or U-shaped once all the points are plotted. The Morrison Creek study area had many warehouses that actually had several different types of occupants because of the partitioned spaces within the building. Because of this variance in occupants, the information from the interviews was averaged to get a composite curve and then compared to a composite curve developed by averaging the S and U-shaped curve. The similarities between the two are shown below and are close enough to validate the use of the TVA study.

DEPTHS OF FLOODING	MORRISON CREEK STUDY	TVA STUDY
3'	53.2%	59.0%
7.5'	77.3%	82.5%
10'	82.8%	82.5%
12.5'	89.6%	86.8%
15'	94.6%	91.2%

The commercial and industrial structures in the West Sacramento area fall primarily in the S-shaped category so that curve was used. It should be noted however that there is only a small difference between the S and U-shaped curves (about 5%) when considering the extremely deep depths of flooding in the study area. As in the case of residential properties the curves were adjusted for foundation elevations.

Some land use categories (e.g. emergency costs) do not have depth-damage curves. These costs were based upon the amount of people affected by the flood, the duration of flooding which is about 5 days, and the estimated amount of time it would take before reentry into the home was possible. Traffic disruption, another category unaffected by depth-damage relationships, was considered on Interstate 80 which has an average daily traffic of 97,000.

Average annual damages are the expected value of damages for a given economic condition and point in time. They are determined by weighing the estimated damages from varying degrees of flooding by their probability of occurrence and may be approximated by measuring the area under the damage-frequency curve using standard mathematical integration procedures. A damages computer program originally created by the Los Angeles District was used to compute the damages and benefits. This economic model has been tested against manual calculations on various projects in the past to verify its accuracy. Table 4 shows estimated damages by probability of occurrence for existing conditions. Figure 5 is a graphic presentation of the information.

Probable average annual damages without the proposed project were estimated for the study year (1990) and the year in which growth will no longer continue to occur (1992). The latter damage figure has been held constant to the year 2098. Since it remains constant, the average annual equivalent damages are also the same and are unaffected by a change in interest rates (see Table 5). The average annual damages are based upon the assumption that the study area will rebuild before the next flood event occurs. Information was gathered on the 1986 flood in the Linda/Olivehurst area in California because depths of flooding had been very deep (8'-10' in some areas) and are somewhat comparable to the anticipated depths of flooding in West Sacramento. The recovery of the flooded area was used to validate the rebuilding assumption used in this analysis.

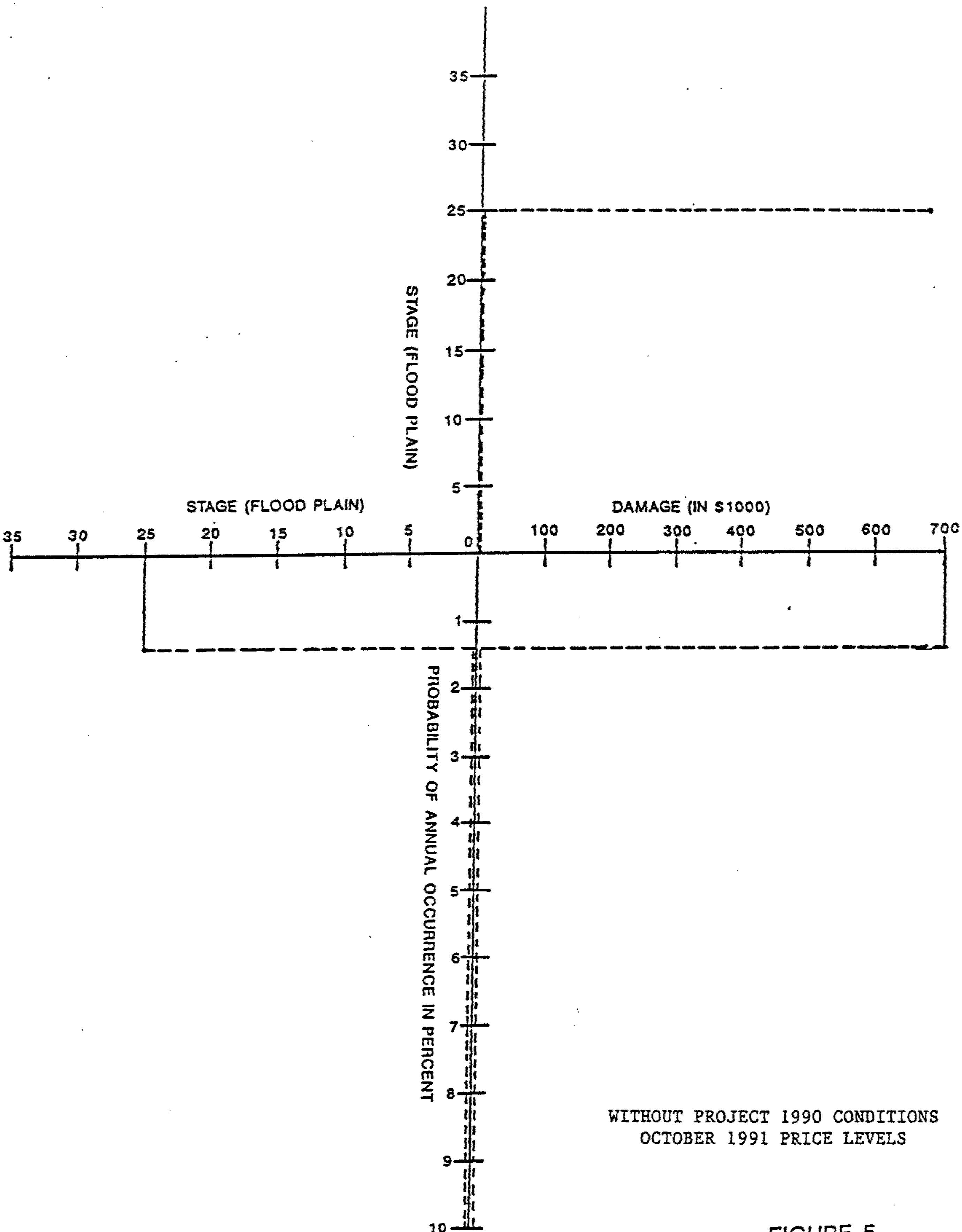
The increase in damages between 1990 and 1992 shown in Table 5 reflects the conversion of some vacant flood plain acres to urban uses. Approximately 71 acres are involved (76% are residential). The residential development is occurring primarily in the Lighthouse Marina Project area (see Figure 8), which is currently under construction. Anticipated future growth in the area will be addressed in more detail in the With Project Conditions section.

With Project Conditions

Urban development is anticipated to occur under with project conditions. The amount of anticipated growth is based upon population projections, employment projections, and the availability of land in West Sacramento. The 1985 OBERS BEA Regional Projections for Sacramento (see Table 6), which includes Sacramento, Yolo, Placer, and El Dorado Counties, were compared with local population projections made by the State of California Department of Finance for Yolo County (December 1986 publication) and for the same four counties used in the OBERS projections. The 1990-2020 time period was used for comparison purposes

Table 4
WITHOUT PROJECT CONDITIONS (1990)
FLOOD DAMAGES FOR SELECTED EVENTS
OCTOBER 1991 PRICE LEVELS (THOUSANDS)

	70 YEAR	PORTIONS AFFECTED BY FEMA 50%	71-1000 YEAR	PORTIONS AFFECTED BY FEMA 50%
SINGLE RESID. STR.	0	0	113,660	0
SINGLE RESID. CONT.	0	0	67,037	0
MULTIPLE RESID. STR.	0	0	40,801	4,852
MULTIPLE RESID. CONT	0	0	28,224	2,906
MOBILE HOME STR.	0	0	18,444	15,854
MOBILE HOME CONT.	0	0	8,226	7,085
COMMERCIAL	0	0	102,125	38,319
INDUSTRIAL	0	0	254,097	111,835
PUBLIC	0	0	47,342	2,837
EMERGENCY COSTS	0	0	10,703	905
AGRICULTURAL	0	0	2,938	0
	$0	$0	$693,597	$184,593



WITHOUT PROJECT 1990 CONDITIONS
OCTOBER 1991 PRICE LEVELS

FIGURE 5

TABLE 5
WITHOUT PROJECT CONDITIONS (1990)
AVERAGE ANNUAL DAMAGES
OCTOBER 1991 PRICE LEVELS (THOUSANDS)

	1990	PORTIONS AFFECTED BY FEMA 50%	1992-2096	PORTIONS AFFECTED BY FEMA 50%	AVERAGE ANNUAL EQUIV. 8-3/4%	PORTIONS AFFECTED FEMA 50%
SINGLE FAMILY RES. STR.	1,624	0	1,675	18	1,675	18
SINGLE FAMILY RES. CONT.	958	0	988	11	988	11
MULTI-FAMILY RES. STR.	583	69	611	69	611	69
MULTI-FAMILY RES. CONT.	402	42	428	42	428	42
MOBILE HOME STR.	263	226	263	226	263	226
MOBILE HOME CONT.	117	101	117	101	117	101
COMMERCIAL	1,459	547	1,459	547	1,459	547
INDUSTRIAL	3,631	1,598	3,692	1,659	3,692	1,659
PUBLIC	639	41	639	41	639	41
EMERGENCY COSTS	152	13	157	14	157	14
AGRICULTURAL	42	0	42	0	42	0
	$9,870	$2,637	$10,071	$2,728	$10,071	$2,728

TABLE 6

Sacramento, CA (MSA)

—Population, Personal Income, and Earnings, 1969–1983, and Projected, 1990–2035

	1969[1]	1973[1]	1978	1983	1990	1995	2000	2005	2015	2035
Population as of July 1 (thousands)	827.4	905.8	1,040.7	1,197.2	1,392.7	1,515.1	1,607.6	1,680.7	1,793.4	1[illegible]
	Millions of 1972 dollars									
Total personal income (place of residence)	3,641.3	4,447.2	5,838.7	6,544.0	8,862.9	10,378.5	11,682.4	12,838.3	14,881.1	18,959.5
By place of work										
Total earnings[2]	2,894.9	3,473.9	4,289.7	4,393.1	6,025.6	7,036.4	7,935.5	8,719.9	9,962.6	12,147.1
Farm	83.1	140.3	100.5	54.8	81.1	84.8	87.0	89.2	95.2	111.3
Nonfarm	2,811.8	3,333.5	4,189.2	4,338.2	5,944.6	6,951.7	7,848.5	8,630.7	9,867.4	12,035.8
Private	1,628.8	1,909.7	2,569.7	2,761.5	4,005.0	4,782.9	5,460.5	6,031.7	6,927.8	8,501.2
Agricultural services, forestry, fisheries, and other[4]	([5])	([5])	24.8	23.6	31.0	36.5	41.3	46.2	53.1	64.8
Mining	([5])	([5])	4.6	10.0	16.8	20.9	24.4	27.5	31.9	40.1
Construction	184.5	235.2	341.0	245.5	419.8	506.4	587.0	657.2	764.0	974.4
Manufacturing	289.6	272.0	326.1	339.9	466.3	538.0	602.1	661.5	762.1	936.2
Nondurable goods	120.1	136.2	([5])	145.6	180.9	197.6	212.9	226.3	251.7	298.3
Durable goods	169.5	135.8	([5])	194.3	285.3	340.5	389.1	435.2	510.3	637.9
Transportation and public utilities	191.9	229.7	292.5	335.6	473.1	560.3	640.2	711.3	819.5	999.7
Wholesale trade	112.6	([5])	194.8	219.0	315.5	369.0	418.1	464.5	535.4	650.6
Retail trade	332.2	394.6	495.5	521.0	679.6	790.6	889.5	967.1	1,082.7	1,326.5
Finance, insurance, and real estate	118.2	131.8	216.0	223.3	378.1	474.5	552.8	613.0	704.4	858.8
Services	383.2	473.9	674.4	843.7	1,224.9	1,486.6	1,705.0	1,883.4	2,174.8	2,650.0
Government and government enterprises	1,183.0	1,423.8	1,619.5	1,576.7	1,939.6	2,168.8	2,388.0	2,599.0	2,939.6	3,534.5
Federal, civilian	321.5	336.6	327.5	330.3	380.2	410.5	441.1	472.1	523.5	621.7
Federal, military	94.6	116.3	84.7	103.1	114.0	120.0	126.0	132.2	146.6	178.9
State and local	766.9	970.9	1,207.3	1,143.4	1,445.3	1,638.3	1,820.9	1,994.6	2,269.6	2,733.9

—Employment by Place of Work, by Industry, 1969–1983, and Projected, 1990–2035

[Thousands of jobs]

	1969[1]	1973[1]	1978	1983	1990	1995	2000	2005	2015	20[illegible]
Total employment	330.4	372.1	463.5	524.9	646.4	718.5	773.6	811.9	845.6	853.5
Farm	10.6	11.8	11.5	10.3	11.0	10.9	10.8	10.8	10.5	10.2
Nonfarm	319.9	360.3	452.0	514.6	635.4	707.6	762.7	801.1	835.1	843.3
Private	193.3	224.9	298.1	343.2	449.4	511.9	559.3	591.7	622.6	634.6
Agricultural services, forestry, fisheries, and other[4]	([5])	([5])	5.1	5.8	7.4	8.5	9.2	9.8	10.3	10.3
Mining	([5])	([5])	.5	.9	1.2	1.4	1.5	1.6	1.7	1.7
Construction	14.4	18.0	27.8	24.2	36.2	41.2	45.5	49.0	52.4	55.0
Manufacturing	25.6	25.2	29.2	30.7	36.0	38.5	40.4	41.8	42.8	42.7
Nondurable goods	12.2	13.1	([5])	14.0	15.3	15.7	16.0	16.1	16.0	15.4
Durable goods	13.3	12.1	([5])	16.6	20.7	22.8	24.4	25.7	26.8	27.3
Transportation and public utilities	18.1	18.6	21.7	24.1	29.3	32.6	35.3	37.4	39.1	39.5
Wholesale trade	11.1	([5])	17.8	21.7	27.7	30.7	33.3	35.5	37.7	38.9
Retail trade	51.6	61.8	81.6	93.4	122.0	139.4	152.9	162.3	171.4	176.6
Finance, insurance, and real estate	13.2	18.0	24.0	30.6	42.8	50.0	55.1	58.3	61.1	61.7
Services	56.4	67.5	90.4	111.9	146.9	169.6	186.0	196.1	206.2	208.3
Government and government enterprises	126.6	135.4	154.0	171.4	186.0	195.7	203.5	209.4	212.5	208.8
Federal, civilian	31.8	28.3	26.8	28.0	28.5	29.0	29.4	29.7	29.6	28.6
Federal, military	15.3	15.2	10.5	13.6	13.6	13.6	13.6	13.6	13.6	13.6
State and local	79.5	91.9	116.6	129.8	143.9	153.2	160.5	166.1	169.3	166.6

See footnotes at end of tables.

West Sacramento
Population: Historical & Projections

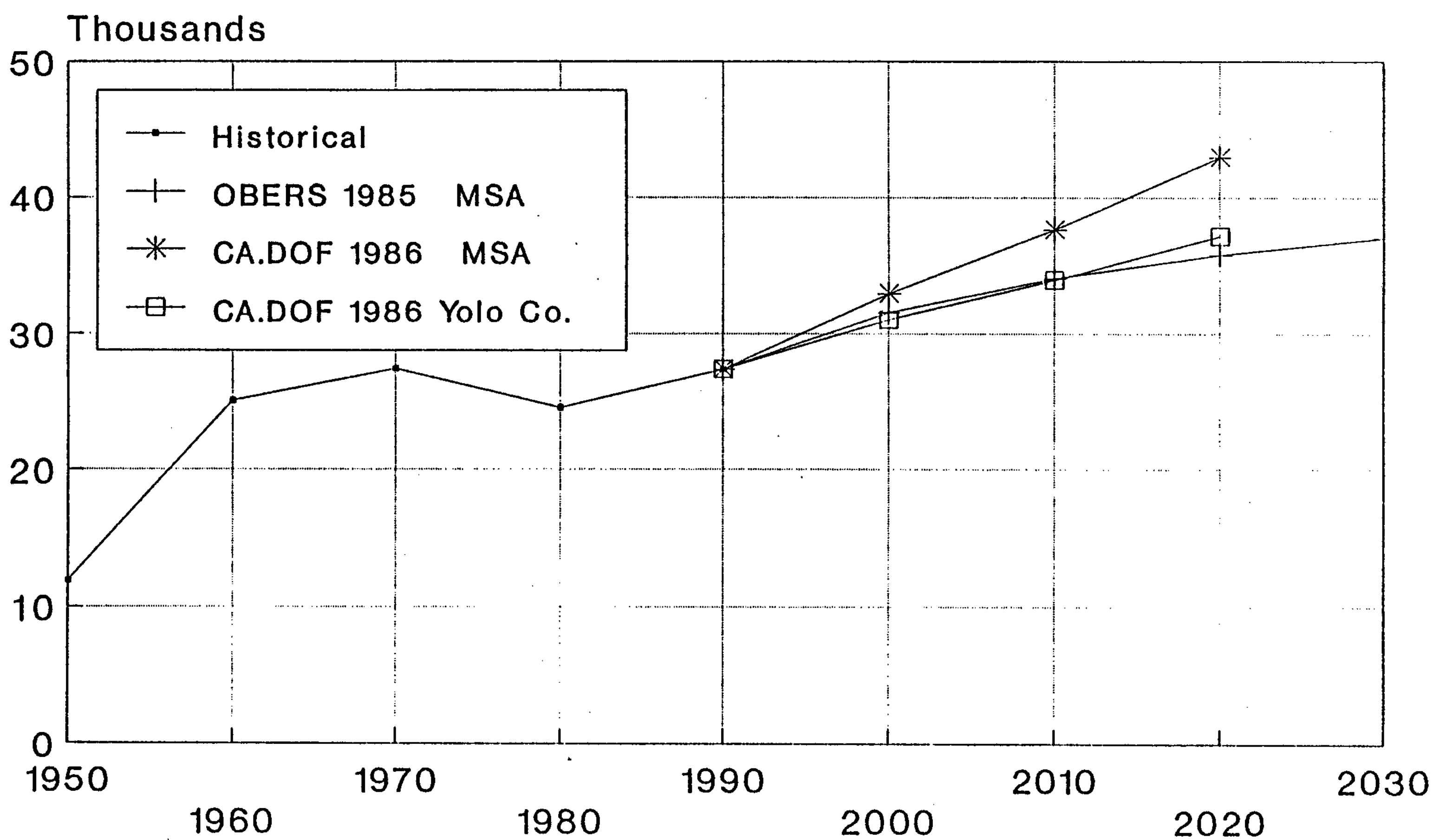


FIGURE 6

because the Department of Finance projections terminated in 2020. The growth rates were applied to West Sacramento's population and are presented graphically in Figure 6. The historical population growth is also presented on the same graph for comparison purposes. Although the OBERS and the Department of Finance four county projection show a significant difference in growth rates (0.9% OBERS vs. 1.5% DOF), the DOF projection for Yolo County is actually much closer to the OBERS rate (0.9% vs. 1.0%). Since the California DOF projections are more recent and more localized in nature, they are being used in this analysis. The historical population growth and the projected growth using DOF data are presented in Table 7. The population is shown for 1992 because it is a key year for the without and with project conditions. The population beyond 1992 would remain stable under the without project condition. Projections beyond the year 2020 for the with project condition (see Table 7) were made by the Corps of Engineers.

Employment projections were also made for West Sacramento based upon several variables: (1) the relationship between population and employment in the OBERS projections (Table 6), (2) the DOF population projections for Yolo County, and (3) the consideration of projects already under construction or projects that will be completed in the near future (e.g. Lighthouse Marina Project, Raley's Landing and the relocation of Sacramento's main post office). The employment projections are presented by category in Table 8.

The availability of land was also considered and the city of West Sacramento General Plan (1990) was used as a guide to determine where the projected growth might occur. Under with project conditions, it was assumed that in 1992, the city would be able to satisfy FEMA's requirement that adequate progress was being made toward project construction, and that the zone A-99 designations would be extended to 1998 (project base year). Growth occurs in three ways:

(1) outside the flood plain
(2) inside the flood plain on acres that are already in urban uses (redevelopment) and
(3) inside the flood plain on acres that are currently vacant or in an agricultural use.

Table 9 shows the amount of acres by land use in categories 2 and 3 (flood plain acres). Figure 7 shows both the existing development and the acres in category 3 (currently vacant or in an agricultural use). The acres in category 2 are in areas planned for redevelopment and include: (1) Lighthouse Marina (2) Broderick-Reuse area and the (3) Central Business District. These sub-areas are displayed in Figure 8 and are located north of the Sacramento River Deep Water Ship Channel.

Several local realtors have indicated that development of the southern part of West Sacramento is constrained because of transportation access problems. Apparently several new bridges would be needed to adequately handle the projected traffic volumes associated with the growth envisioned in the General Plan. The bridges and their locations were identified in the final EIR for the City of West Sacramento General Plan (April 2,

TABLE 7
WEST SACRAMENTO
POPULATION

YEAR	WITHOUT PROJECT POPULATION	WITH PROJECT POPULATION
1950	11,910	N/A
1960	25,030	N/A
1970	27,390	N/A
1980	24,520	N/A
1985	26,330	N/A
1988	27,540	N/A
1989	27,530	N/A
1990	27,350	N/A
1992	28,120	28,120
1998	28,120	30,270
2008	28,120	33,370
2018	28,120	36,510
2028	28,120	39,990
2038	28,120	43,780
2048	28,120	47,930

TABLE 8
WEST SACRAMENTO
EMPLOYMENT PROJECTIONS

	1990	1992	1998	2008	2018	2028	2038	2048
COMMERCIAL	6,300	8,500	10,920	11,880	12,260	12,560	12,880	13,260
INDUSTRIAL	4,600	4,800	5,120	5,700	6,220	6,820	7,440	8,160
PUBLIC	2,100	2,100	4,260	4,900	4,900	4,900	4,900	4,900

TABLE 9
FUTURE GROWTH IN FLOOD PLAIN
IN ACRES

LAND USE	1992	1998	2008	2018	2028	2038	2048	*TOTAL*
<u>RESIDENTIAL</u>								
REDEVELOPED	4.8	0	7.7	31.0	1.4	5.8	0	*50.7*
VACANT	53.6	35.2	56.4	151.2	194.0	207.9	223.1	*921.4*
<u>COMMERCIAL</u>								
REDEVELOPED	0	0	0.2	1.0	0	0	0.1	*1.3*
VACANT	0	0	0	3.7	16.0	8.9	15.8	*44.4*
<u>INDUSTRIAL</u>								
REDEVELOPED	0	0	0	0	0	0	0	*0*
VACANT	17.2	49.8	79.0	82.5	70.4	55.5	60.8	*415.2*
<u>PUBLIC</u>								
REDEVELOPED	0	0	0	0	0	0	0	*0*
VACANT	0	82.1	4.6	0	0	0	0	*86.7*

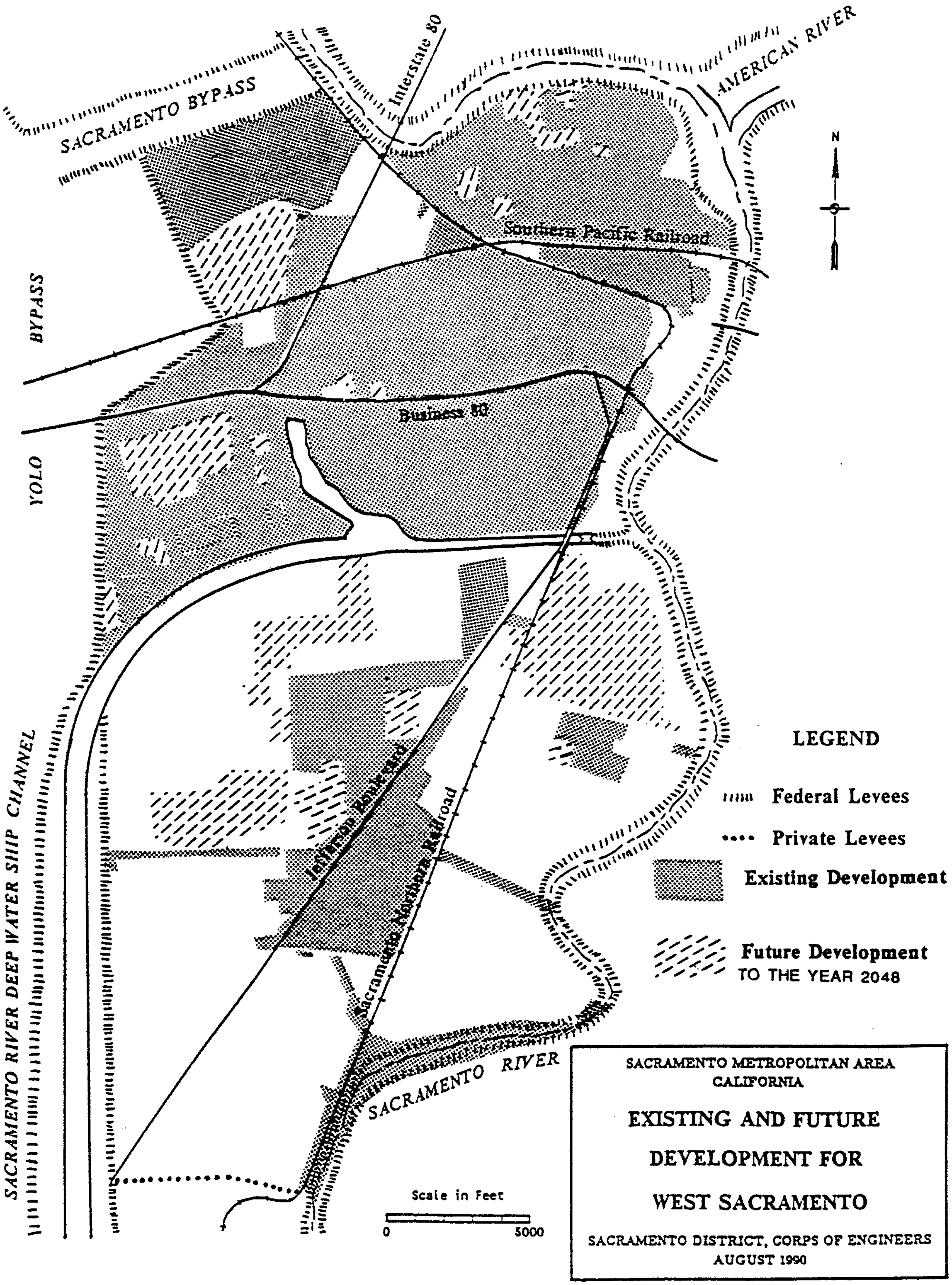

SACRAMENTO BYPASS
Interstate 80
AMERICAN RIVER
Southern Pacific Railroad
BYPASS
YOLO
Business 80
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
Jefferson Boulevard
Sacramento Northern Railroad
SACRAMENTO RIVER
N
LEGEND
Federal Levees
Private Levees
Existing Development
Future Development
TO THE YEAR 2048
Scale in Feet
0
5000
SACRAMENTO METROPOLITAN AREA
CALIFORNIA
EXISTING AND FUTURE
DEVELOPMENT FOR
WEST SACRAMENTO
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
AUGUST 1990

FIGURE 7

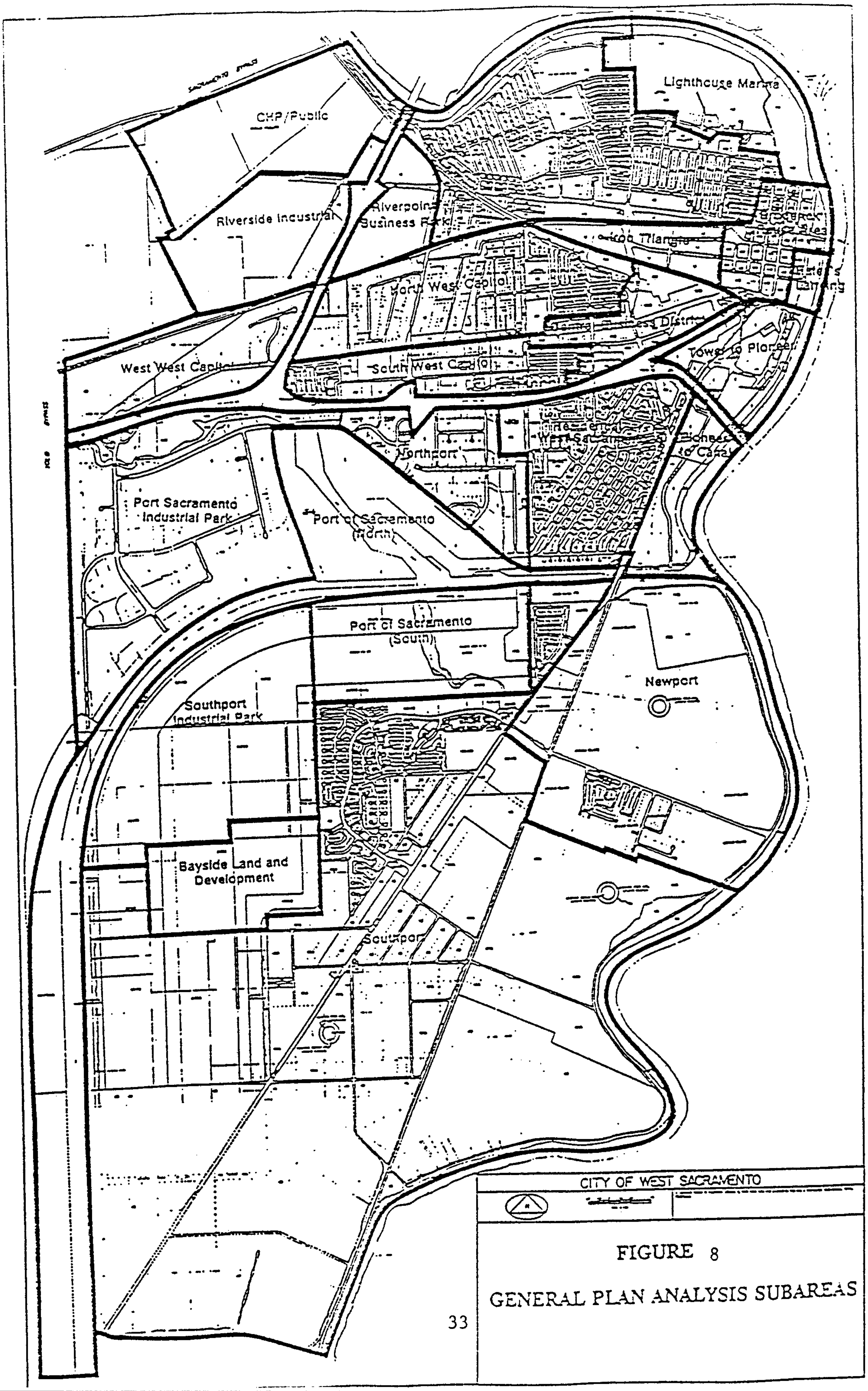


FIGURE 8

GENERAL PLAN ANALYSIS SUBAREAS

1990). The combination of crossings to serve the projected traffic volumes include crossings at Jefferson, Industrial Enterprise, South River Road and Sutterville Road. Local planning officials were contacted to discuss the time sequence and areas in which growth would occur, and it was assumed that any bridge or roads necessary to accommodate the new development would be built when the need arises.

1. <u>Benefit Evaluation</u>

Benefits that accrue from the evaluation of flood control projects include inundation reduction benefits, location benefits, employment benefits, intensification benefits, flood insurance program benefits and savings in flood proofing costs.

Inundation reduction benefits were estimated by evaluating damages with and without a project. Various levels of protection were considered for the existing structures and those structures that would be built prior to 1992. The inundation reduction benefits with and without freeboard (design) are presented in Table 10. They are divided into two categories: (1) those that are not affected by FEMA's 50 percent requirement and (2) those that are affected. The latter category was handled separately because the benefits can be either the cost of relocation or the actual damages that would be sustained if the structures remained in the flood plain. The lesser of the two is the inundation reduction benefit. A cursory analysis showed that the annualized depreciated structure value alone (excluding land and other relocation expenses) exceeded the actual damages that would occur by a wide margin.

In accordance with the planning guidance for determining flood damage prevention benefits in the freeboard range, benefits can be claimed for one-half of the area under the frequency-damage curve between the design level of protection and the largest flood that might be carried within the freeboard. Due to hydraulic assumptions upstream of the study area, no appreciable flow enters the Yolo Bypass beyond the 400-year flood event. Therefore, the 400-year flood would essentially be the maximum event possible in the study area. To derive additional benefits from the freeboard, benefits for each design (100-, 200-, and 400-year) were averaged with the benefits for the largest flood that can be carried within the freeboard (400-year). Equivalent average annual benefits that include benefits in the freeboard range are \$5.7, \$7.4, \$8.3 million for the 100-, 200- and 400-year alternatives. Inundation reduction benefits by land use category for the selected plan (400-year) are shown in Table 11. Additional information on the engineering aspects of freeboard is provided in Appendix D, Section 5.

Location benefits were also considered in the study area because the extremely deep depths of flooding made it impractical to assume standard floodproofing practices such as the use of fill. There is not any directly comparable flood-free land outside the immediate study area when considering some of the current infrastructural advantages of West Sacramento including freeways such as Interstate 80, railroads such as the Southern Pacific Railroad, and waterways such as the Sacramento River Deep Water Ship Channel which allows access to the Port of

TABLE 10
AVERAGE ANNUAL EQUIVALENT DAMAGES AND BENEFITS
OCT. 1991 PRICE LEVELS - 8 3/4% INTEREST RATE

	DAMAGES	BENEFITS
WITHOUT PROJECT [1]	7,344,000	N/A
DESIGN		
WITH PROJECT (100YR)	5,138,000	2,206,000
WITH PROJECT (200YR)	2,568,000	4,776,000
WITH PROJECT (400YR)	1,285,000	6,059,000
WITH FREEBOARD		
WITH PROJECT (100YR)	1,285,000	6,059,000
WITH PROJECT (200YR)	1,285,000	6,059,000
WITH PROJECT (400YR)	1,285,000	6,059,000
WITHOUT PROJECT [2]	2,728,000	N/A
DESIGN		
WITH PROJECT (100YR)	1,909,000	819,000
WITH PROJECT (200YR)	954,000	1,774,000
WITH PROJECT (400YR)	477,000	2,251,000
WITH FREEBOARD		
WITH PROJECT (100YR)	477,000	2,251,000
WITH PROJECT (200YR)	477,000	2,251,000
WITH PROJECT (400YR)	477,000	2,251,000
LOCATION [3]	N/A	N/A
WITH PROJECT (100YR)	N/A	1,412,000
WITH PROJECT (200YR)	N/A	1,412,000
WITH PROJECT (400YR)	N/A	1,412,000

[1] Excludes structures affected by FEMA'S 50 percent requirement.
[2] Structures affected by FEMA'S 50 percent requirement. Relocation of these structures was considered as a way to quantify the benefits attributable to the project because the depths of flooding are too deep. The depreciated value for the structures is approximately $125 million ($11 million at 8 3/4%) which exceeds the damages that would actually occur. The limitation on the amount of benefits being claimed is therefore the actual damages that would occur if the structures remain in the flood plain.
[3] The limit on the amount of location benefits is the expected damages that the new activity would have for without project conditions. The benefits claimed for all of the levels of protection met this criteria.

TABLE 11
INUNDATION REDUCTION BENEFITS
BY LAND USE CATEGORY (SELECTED PLAN)
($1,000)

LAND USE CATEGORY	WITHOUT PROJECT DAMAGES	WITH PROJECT DAMAGES	BENEFITS
RESIDENTIAL	4,084	714	3,370
COMMERCIAL	1,459	255	1,204
INDUSTRIAL	3,691	646	3,045
PUBLIC & SEMI-PUBLIC	582	102	480
AUTOS- TRAFFIC DISRUPTION	57	10	47
EMERGENCY COSTS	157	28	129
AGRICULTURAL	42	7	35
TOTAL	*10,072*	*1,762*	*8,310*

Sacramento. There is a current problem with access in terms of bridges but that has already been discussed in the section entitled, "With Project Conditions."

Location benefits occur when a reduction in the level of flood risk makes it profitable for new activities to locate in the flood plain. In this study area, it has been assumed that growth after 1992 will only occur with a project in place, so all vacant acres upon which this growth is projected to occur are acres with a locational advantage. Location benefits were calculated for the vacant acres displayed in Table 9 (and shown graphically in Figure 7) using the change in market value approach.

It was assumed that raw land (unimproved land) would be converted to the higher valued improved land under with project conditions and under the without project condition would remain agricultural crop land (valued at $5,000 per acre). The values assigned to lands and development costs are based upon phone interviews with private developers in West Sacramento, City of West Sacramento planning personnel, Taxation Consultants working for the City of West Sacramento, Coldwell Banker Realtors, Yolo County Assessors, and Sacramento District Corps of Engineers Appraisers.

Table 12 shows the computations by year and land use category. The total acres for Year 1 relates to the growth that is projected to occur between 1992 and 1993. The acres in this table are based upon the projected growth shown in Table 9. The total benefit amounted to approximately $36 million, however, an adjustment had to be made to account for the residual damages that would now be incurred by the new structures. After the adjustment was made the benefits were the following for the various levels of protection:

100 year	-	$35,660,000
200 year	-	$35,828,000
400 year	-	$35,911,000

The limit on the amount of location benefits is the expected damages that the new structures would have for without project conditions. This has been calculated to be $1,412,000 which is lower than the numbers shown above for all of the levels of protection so the actual damages are now the benefit (see Table 10). Table 13 shows not only the breakdown of this number by land use category but also the average annual damages over time. This table is based upon the growth information presented in Table 9.

Projects that provide land enhancement benefits of unconscionable magnitude to a few beneficiaries are subject to special cost sharing. This category of benefits are known as windfall benefits. Location benefits are claimed on approximately 1,400 acres, and 83% of this acreage is owned by 16 landowners. However, these landowners are not the only beneficiaries of the proposed flood control project. There are approximately 12,000 acres within the study area with a population of about 28,000. There are currently over 10,600 residential structures valued at over $580 million. Even though there are 16 landowners who may at some future time benefit

TABLE 12
SACRAMENTO METRO STUDY
WEST SACRAMENTO LOCATION BENEFITS (COMMERCIAL-INDUSTRIAL-PUBLIC)

YEAR	VALUE PER ACRE W/PROJ.	VALUE PER ACRE W/O PROJ.	DEVELOP. COSTS PER ACRE	NET DIFFERENCE IN VALUE	TOTAL ACRES	TOTAL VALUE	PRESENT WORTH FACTOR 8-3/4%	PRESENT WORTH AMOUNT ($)
1	207,000	5,000	40,000	162,000	28.8	$4,665,600	0.9196	$4,290,486
2	207,000	5,000	40,000	162,000	57.6	$9,331,200	0.8456	$7,890,463
3	207,000	5,000	40,000	162,000	86.5	$14,013,000	0.7776	$10,896,509
4	207,000	5,000	40,000	162,000	115.3	$18,678,600	0.7150	$13,355,199
5	207,000	5,000	40,000	162,000	123.6	$20,023,200	0.6575	$13,165,254
6	207,000	5,000	40,000	162,000	132.0	$21,384,000	0.6046	$12,928,766
7	207,000	5,000	40,000	162,000	140.3	$22,728,600	0.5559	$12,634,829
8	207,000	5,000	40,000	162,000	148.6	$24,073,200	0.5112	$12,306,220
9	207,000	5,000	40,000	162,000	157.0	$25,434,000	0.4701	$11,956,523
10	207,000	5,000	40,000	162,000	165.3	$26,778,600	0.4323	$11,576,389
11	207,000	5,000	40,000	162,000	173.6	$28,123,200	0.3975	$11,178,972
12	207,000	5,000	40,000	162,000	181.9	$29,467,800	0.3655	$10,770,481
13	207,000	5,000	40,000	162,000	190.3	$30,828,600	0.3361	$10,361,49[illegible]
14	207,000	5,000	40,000	162,000	198.6	$32,173,200	0.3091	$9,944,7[illegible]
15	207,000	5,000	40,000	162,000	207.0	$33,534,000	0.2842	$9,530,363
16	207,000	5,000	40,000	162,000	215.5	$34,911,000	0.2613	$9,122,244
17	207,000	5,000	40,000	162,000	224.0	$36,288,000	0.2403	$8,720,006
18	207,000	5,000	40,000	162,000	232.4	$37,648,800	0.2210	$8,320,385
19	207,000	5,000	40,000	162,000	240.8	$39,009,600	0.2032	$7,926,751
20	207,000	5,000	40,000	162,000	249.3	$40,386,600	0.1869	$7,548,256
21	207,000	5,000	40,000	162,000	257.8	$41,763,600	0.1718	$7,174,986
22	207,000	5,000	40,000	162,000	266.2	$43,124,400	0.1580	$6,813,655
23	207,000	5,000	40,000	162,000	274.6	$44,485,200	0.1453	$6,463,700
24	207,000	5,000	40,000	162,000	283.1	$45,862,200	0.1336	$6,127,190
25	207,000	5,000	40,000	162,000	292.4	$47,368,800	0.1229	$5,821,626
26	207,000	5,000	40,000	162,000	301.6	$48,859,200	0.1130	$5,521,090
27	207,000	5,000	40,000	162,000	310.9	$50,365,800	0.1039	$5,233,007
28	207,000	5,000	40,000	162,000	320.2	$51,872,400	0.0955	$4,953,814
29	207,000	5,000	40,000	162,000	329.4	$53,362,800	0.0879	$4,690,590
30	207,000	5,000	40,000	162,000	338.7	$54,869,400	0.0808	$4,433,448
31	207,000	5,000	40,000	162,000	348.0	$56,376,000	0.0743	$4,188,737
32	207,000	5,000	40,000	162,000	357.3	$57,882,600	0.0683	$3,953,382
33	207,000	5,000	40,000	162,000	366.5	$59,373,000	0.0628	$3,728,624
34	207,000	5,000	40,000	162,000	375.8	$60,879,600	0.0578	$3,518,841
35	207,000	5,000	40,000	162,000	381.9	$61,867,800	0.0531	$3,285,180

36	207,000	5,000	40,000	162,000	388.1	$62,872,200	0.0489	$3,074,451
37	207,000	5,000	40,000	162,000	394.2	$63,860,400	0.0449	$2,867,332
38	207,000	5,000	40,000	162,000	400.4	$64,864,800	0.0413	$2,678,916
39	207,000	5,000	40,000	162,000	406.5	$65,853,000	0.0380	$2,502,414
40	207,000	5,000	40,000	162,000	412.6	$66,841,200	0.0350	$2,339,442
41	207,000	5,000	40,000	162,000	418.8	$67,845,600	0.0321	$2,177,844
42	207,000	5,000	40,000	162,000	424.9	$68,833,800	0.0296	$2,037,480
43	207,000	5,000	40,000	162,000	431.1	$69,838,200	0.0272	$1,899,599
44	207,000	5,000	40,000	162,000	437.2	$70,826,400	0.0250	$1,770,660
45	207,000	5,000	40,000	162,000	444.8	$72,057,600	0.0230	$1,657,325
46	207,000	5,000	40,000	162,000	452.4	$73,288,800	0.0211	$1,546,394
47	207,000	5,000	40,000	162,000	460.0	$74,520,000	0.0195	$1,453,140
48	207,000	5,000	40,000	162,000	467.6	$75,751,200	0.0179	$1,355,946
49	207,000	5,000	40,000	162,000	475.2	$76,982,400	0.0165	$1,270,210
50	207,000	5,000	40,000	162,000	482.9	$78,229,800	0.0151	$1,181,270
51	207,000	5,000	40,000	162,000	490.5	$79,461,000	0.0139	$1,104,508
52	207,000	5,000	40,000	162,000	498.1	$80,692,200	0.0128	$1,032,860
53	207,000	5,000	40,000	162,000	505.7	$81,923,400	0.0118	$966,696
54	207,000	5,000	40,000	162,000	513.3	$83,154,600	0.0108	$898,070
55	207,000	5,000	40,000	162,000	521.1	$84,418,200	0.0100	$844,182
56	207,000	5,000	40,000	162,000	529.1	$85,714,200	0.0092	$788,571
57–100	207,000	5,000	40,000	162,000	529.1	$85,714,200	0.1039	$8,905,705
						TOTAL PRESENT WORTH		$324,685,207
						ANNUAL EQUIVALENT LOCATION BENEFITS		$28,416,449

TABLE 12 (CON'T)
SACRAMENTO METRO STUDY
WEST SACRAMENTO LOCATION BENEFITS (RESIDENTIAL)

YEAR	VALUE PER ACRE W/PROJ.	VALUE PER ACRE W/O PROJ.	DEVELOP. COSTS PER ACRE	NET DIFFERENCE IN VALUE	TOTAL ACRES	TOTAL VALUE	PRESENT WORTH FACTORS 8–3/4%	PRESENT WORTH AMOUNT ($)
1	117,000	5,000	40,000	72,000	7.0	$504,000	0.9196	$463,478
2	117,000	5,000	40,000	72,000	14.0	$1,008,000	0.8456	$852,365
3	117,000	5,000	40,000	72,000	21.1	$1,519,200	0.7776	$1,181,330
4	117,000	5,000	40,000	72,000	28.1	$2,023,200	0.7150	$1,446,588
5	117,000	5,000	40,000	72,000	31.6	$2,275,200	0.6575	$1,495,944
6	117,000	5,000	40,000	72,000	35.2	$2,534,400	0.6046	$1,532,298
7	117,000	5,000	40,000	72,000	38.7	$2,786,400	0.5559	$1,548,960
8	117,000	5,000	40,000	72,000	42.2	$3,038,400	0.5112	$1,553,230
9	117,000	5,000	40,000	72,000	45.7	$3,290,400	0.4701	$1,546,817
10	117,000	5,000	40,000	72,000	49.2	$3,542,400	0.4323	$1,531,380
11	117,000	5,000	40,000	72,000	52.8	$3,801,600	0.3975	$1,511,136
12	117,000	5,000	40,000	72,000	56.3	$4,053,600	0.3655	$1,481,591
13	117,000	5,000	40,000	72,000	59.8	$4,305,600	0.3361	$1,447,1[illegible]
14	117,000	5,000	40,000	72,000	63.4	$4,564,800	0.3091	$1,410,98[illegible]
15	117,000	5,000	40,000	72,000	77.5	$5,580,000	0.2842	$1,585,836
16	117,000	5,000	40,000	72,000	91.6	$6,595,200	0.2613	$1,723,326
17	117,000	5,000	40,000	72,000	105.6	$7,603,200	0.2403	$1,827,049
18	117,000	5,000	40,000	72,000	119.7	$8,618,400	0.2210	$1,904,666
19	117,000	5,000	40,000	72,000	133.8	$9,633,600	0.2032	$1,957,548
20	117,000	5,000	40,000	72,000	147.9	$10,648,800	0.1869	$1,990,261
21	117,000	5,000	40,000	72,000	162.0	$11,664,000	0.1718	$2,003,875
22	117,000	5,000	40,000	72,000	176.0	$12,672,000	0.1580	$2,002,176
23	117,000	5,000	40,000	72,000	190.1	$13,687,200	0.1453	$1,988,750
24	117,000	5,000	40,000	72,000	204.2	$14,702,400	0.1336	$1,964,241
25	117,000	5,000	40,000	72,000	223.5	$16,092,000	0.1229	$1,977,707
26	117,000	5,000	40,000	72,000	242.8	$17,481,600	0.1130	$1,975,421
27	117,000	5,000	40,000	72,000	262.0	$20,260,800	0.1039	$2,105,097
28	117,000	5,000	40,000	72,000	281.4	$21,650,400	0.0955	$2,067,613
29	117,000	5,000	40,000	72,000	300.7	$23,032,800	0.0879	$2,024,583
30	117,000	5,000	40,000	72,000	319.9	$24,422,400	0.0808	$1,973,330
31	117,000	5,000	40,000	72,000	339.2	$25,812,000	0.0743	$1,917,832
32	117,000	5,000	40,000	72,000	358.5	$27,201,600	0.0683	$1,857,869
33	117,000	5,000	40,000	72,000	377.8	$28,591,200	0.0628	$1,795,527
34	117,000	5,000	40,000	72,000	397.1	$30,016,800	0.0578	$1,734,971
35	117,000	5,000	40,000	72,000	416.9	$31,449,600	0.0531	$1,669,974

36	117,000	5,000	40,000	72,000	436.8	$32,875,200	0.0489	$1,607,597
37	117,000	5,000	40,000	72,000	456.6	$34,300,800	0.0449	$1,540,106
38	117,000	5,000	40,000	72,000	476.4	$35,726,400	0.0413	$1,475,500
39	117,000	5,000	40,000	72,000	496.2	$37,152,000	0.0380	$1,411,776
40	117,000	5,000	40,000	72,000	516.0	$38,577,600	0.0350	$1,350,216
41	117,000	5,000	40,000	72,000	535.8	$40,010,400	0.0321	$1,284,334
42	117,000	5,000	40,000	72,000	555.7	$41,436,000	0.0296	$1,226,506
43	117,000	5,000	40,000	72,000	575.5	$42,861,600	0.0272	$1,165,836
44	117,000	5,000	40,000	72,000	595.3	$44,640,000	0.0250	$1,116,000
45	117,000	5,000	40,000	72,000	620.0	$46,418,400	0.0230	$1,067,623
46	117,000	5,000	40,000	72,000	644.7	$48,182,400	0.0211	$1,016,649
47	117,000	5,000	40,000	72,000	669.2	$49,960,800	0.0195	$974,236
48	117,000	5,000	40,000	72,000	693.9	$51,739,200	0.0179	$926,132
49	117,000	5,000	40,000	72,000	718.6	$53,510,400	0.0165	$882,922
50	117,000	5,000	40,000	72,000	743.2	$55,281,600	0.0151	$834,752
51	117,000	5,000	40,000	72,000	767.8	$57,060,000	0.0139	$793,134
52	117,000	5,000	40,000	72,000	792.5	$58,838,400	0.0128	$753,132
53	117,000	5,000	40,000	72,000	817.2	$60,609,600	0.0118	$715,193
54	117,000	5,000	40,000	72,000	841.8	$61,545,600	0.0108	$664,692
55	117,000	5,000	40,000	72,000	854.8	$62,481,600	0.0100	$624,816
56	117,000	5,000	40,000	72,000	867.8	$62,481,600	0.0092	$574,831
7-100	117,000	5,000	40,000	72,000	867.8	$62,481,600	0.1039	$6,491,838

TOTAL PRESENT WORTH $87,548,679

ANNUAL EQUIVALENT LOCATION BENEFITS $7,662,260

TABLE 13
WITHOUT PROJECT DAMAGES 1]
OCTOBER 1991 PRICE LEVELS – 8–3/4% INTEREST RATE
($1,000)

	1992	1998	2008	2018	2028	2038	2048–2058	AVERAGE ANNUAL EQUIVALENT
RESIDENTIAL	0	120	261	651	1,168	1,656	2,136	446
COMMERCIAL	0	0	0	24	128	177	263	26
INDUSTRIAL	0	167	398	668	930	1,200	1,447	468
PUBLIC	0	400	500	500	500	500	500	460
EMERGENCY COSTS	0	4	7	17	31	49	66	12
TOTAL	*0*	*691*	*1,166*	*1,860*	*2,757*	*3,582*	*4,412*	*1,412*

1] DAMAGES ASSOCIATED WITH NEW DEVELOPMENT BUILT ON LOCATION ACRES

financially from a Federal project in West Sacramento, there are many people who would benefit only from the flood protection. Accordingly, it is believed that special cost sharing due to locational advantages is not appropriate for West Sacramento.

Employment benefits are not being claimed because Yolo county is not qualified using the current unemployment criteria. Savings in floodproofing cost are not applicable for this project because of the growth assumptions (none after 1992) for the without project conditions.

There is a national cost associated with the administration of the flood insurance program. The cost of servicing flood insurance policies in effect at the time of the study is the average cost per policy, including agent commissions, and the costs of servicing and claims adjusting. This national flood insurance program operating cost is currently $77 per policy (see Economic Guidance Memorandum #89-3).

It was assumed that 10 percent of the structures within the flood plain would have flood insurance. The 10 percent is based upon discussion with a local FEMA official. Since the same amount of structures are located in all of the flood frequency events, the benefit remains the same for all of the levels of protection. The benefits associated with the flood insurance program are $88,000.

In summary, the following flood control benefits were claimed for the project: inundation reduction, location benefits and flood insurance program benefits. The total average annual equivalent flood control benefits are $7.2, $8.9 and $9.8 million for the 100-, 200- and 400-year alternatives.

SACRAMENTO METROPOLITAN AREA, CALIFORNIA

FEASIBILITY REPORT

APPENDIX B

COMPARISON OF FLOOD CONTROL MEASURES

COMPARISON OF FLOOD CONTROL MEASURES

DESCRIPTION OF ALTERNATIVE PLANS

Several flood control measures were considered for further analysis. These measures focused on five major areas: modification of Fremont Weir and Yolo Bypass; modification of Sacramento Weir and Bypass; diversion of floodwaters into the Ship Channel; modification of levees around West Sacramento; and removal of flow constrictions from the Yolo Bypass. Within each measure, several options were developed to satisfy the planning objectives. The following is a description of each measure.

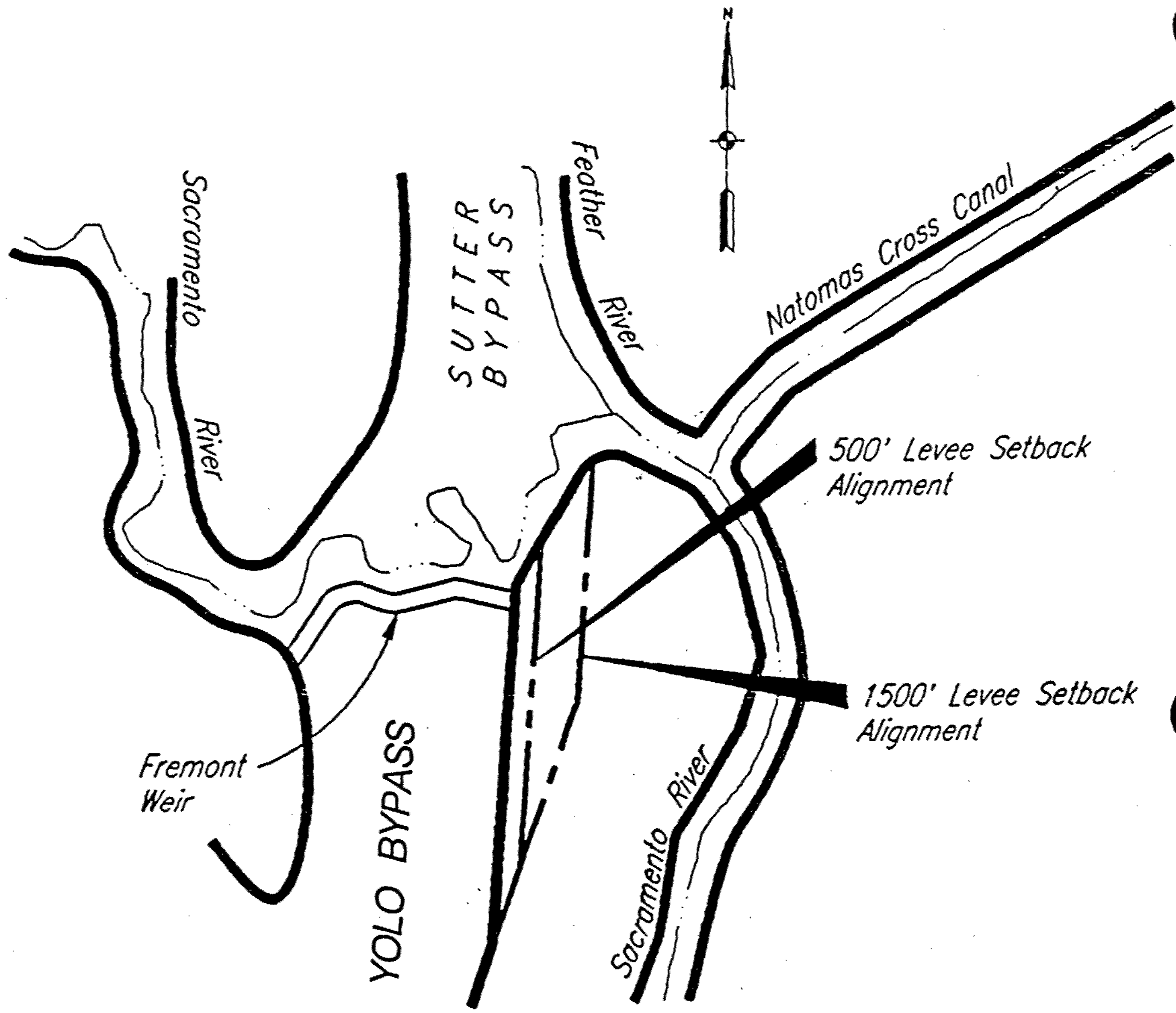
Modify Fremont Weir and Yolo Bypass

The following options focus on facilitating or improving the conveyance of the Fremont Weir and the Yolo Bypass, thereby diverting greater flows into the Yolo Bypass.

Option 1. - Remove the deposited material both upstream and downstream of the Fremont Weir to an elevation less than or equal to the weir crest elevation of 30.4 feet. The DWR has recently (1986 and 1987) undertaken efforts to lower the elevation of sediment upstream and downstream of the Fremont Weir to an elevation of 27 to 28 feet. A portion of this work on the east side of the bypass (approximately 375 acres) has not been completed. For this option, approximately 200,000 cy of additional material would be removed to ensure that land surface elevations are generally no higher than 30.4 feet. Material would either be deposited on nearby land as fill or used to improve existing levees on the Yolo Bypass or Sacramento River.

Option 2. - Widen the Fremont Weir and the Yolo Bypass at Fremont Weir by 500 or 1,500 feet. The east levee of the Yolo Bypass would be set back in order to better align the inlet to the Yolo Bypass with the outlet of the Sutter Bypass. The length of levee to be set back (in a landward direction) is approximately 18,400 linear feet for the 500-foot option and 21,600 linear feet for the 1,500-foot option. Alignment of the proposed setbacks are shown in Figure 1. The weir would be extended 500 or 1,500 feet and would be constructed to match the current design. This option also considered the modification of about 400 feet of embankment material along the Fremont Weir at its junction with the Old River. The embankment material would be replaced with a concrete weir and riprap to match the current design.

Option 3. - Lower the crest elevation of the Fremont Weir by 0.5 or 1.0 foot. This would involve lowering and reshaping approximately 9,120 linear feet of concrete weir. To ensure proper functioning of the weir at these elevations, additional



NOT TO SCALE

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

MODIFY FREMONT WEIR
AND YOLO BYPASS

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1989

FIGURE 1

sediment removal would be necessary to lower the land surface to an elevation equal to or less than the weir crest elevations. Approximately 400,000 and 600,000 cy of material would need to be removed and disposed of when lowering the weir by 0.5 and 1.0 foot, respectively. Again, the area of sediment removal (approximately 375 acres) would be confined to the east side of the bypass that has not been modified by the DWR. (Not all of the area within the 375 acres would be impacted by construction activities because of irregularities in the ground surface elevations.)

Modify Sacramento Weir and Bypass

Several options to modify the Sacramento Weir and/or its operation in order to divert additional floodwaters into the Yolo Bypass were considered. The Sacramento Weir consists of 48 bays (gates) that are manually operated. To adjust the flow that passes over the weir, the bays are opened individually as specified in the operating criteria. Each bay consists of 36, 3 by 12-inch wooden planks that are approximately 6 feet long. The effective overflow weir crest elevation is 21.5 feet. Traffic from Highway 16 and the UPRR would need to be rerouted or diverted during any construction involving the weir.

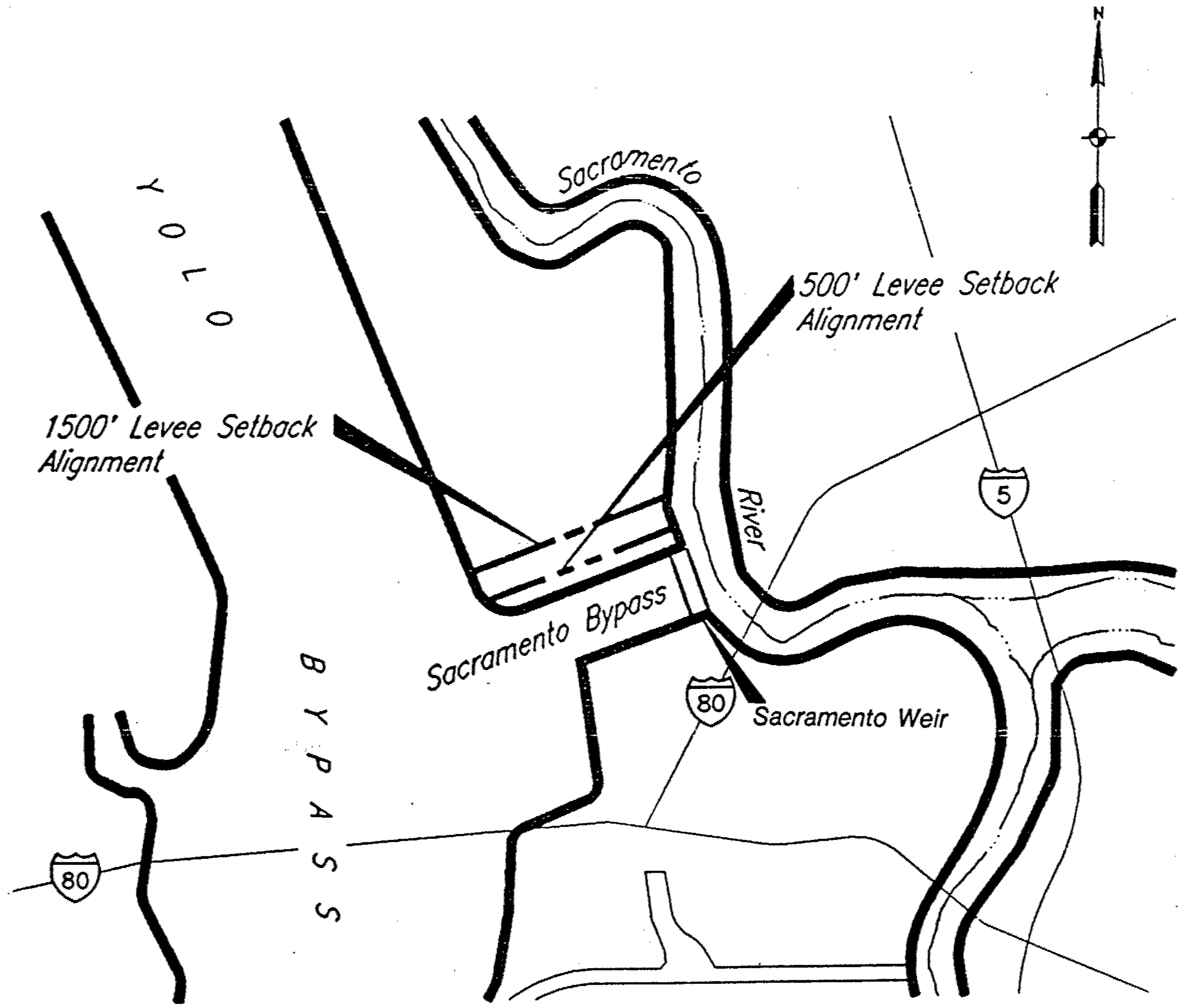
Option 1. - Remove the existing gate structures and form a smooth concrete surface along the weir with a crest elevation of 21.2 feet. The length of weir to be modified is approximately 1,824 feet.

Option 2. - Widen the Sacramento Weir and set back the north levee of the Sacramento Bypass by 500 or 1,500 feet in a landward direction. The north levee (approximately 9,500 feet) was selected because land north of the bypass is relatively undeveloped. Alignment of the proposed setbacks is shown in Figure 2. The design of the weir extension would match that of the current design. Operation of the gates would remain the same as the existing operation.

Option 3. - Lower the weir crest by either 0.5 of 1.0 foot while retaining the same gate configuration by extending the boards to their original elevation.

Divert Floodwaters into the Sacramento River Deep Water Ship Channel

This measure involves the diversion of a portion of the floodwaters (between 20,000 and 40,000 cfs) in the Yolo Bypass and/or the Sacramento River into the Ship Channel (Figure 3). This would be done by using pumps and diversion facilities that connect the Sacramento River and Yolo Bypass to the Ship Channel near the Port. This alternative would also require the relocation of Port facilities and new levees on both sides of the Ship Channel adjacent to the Port.



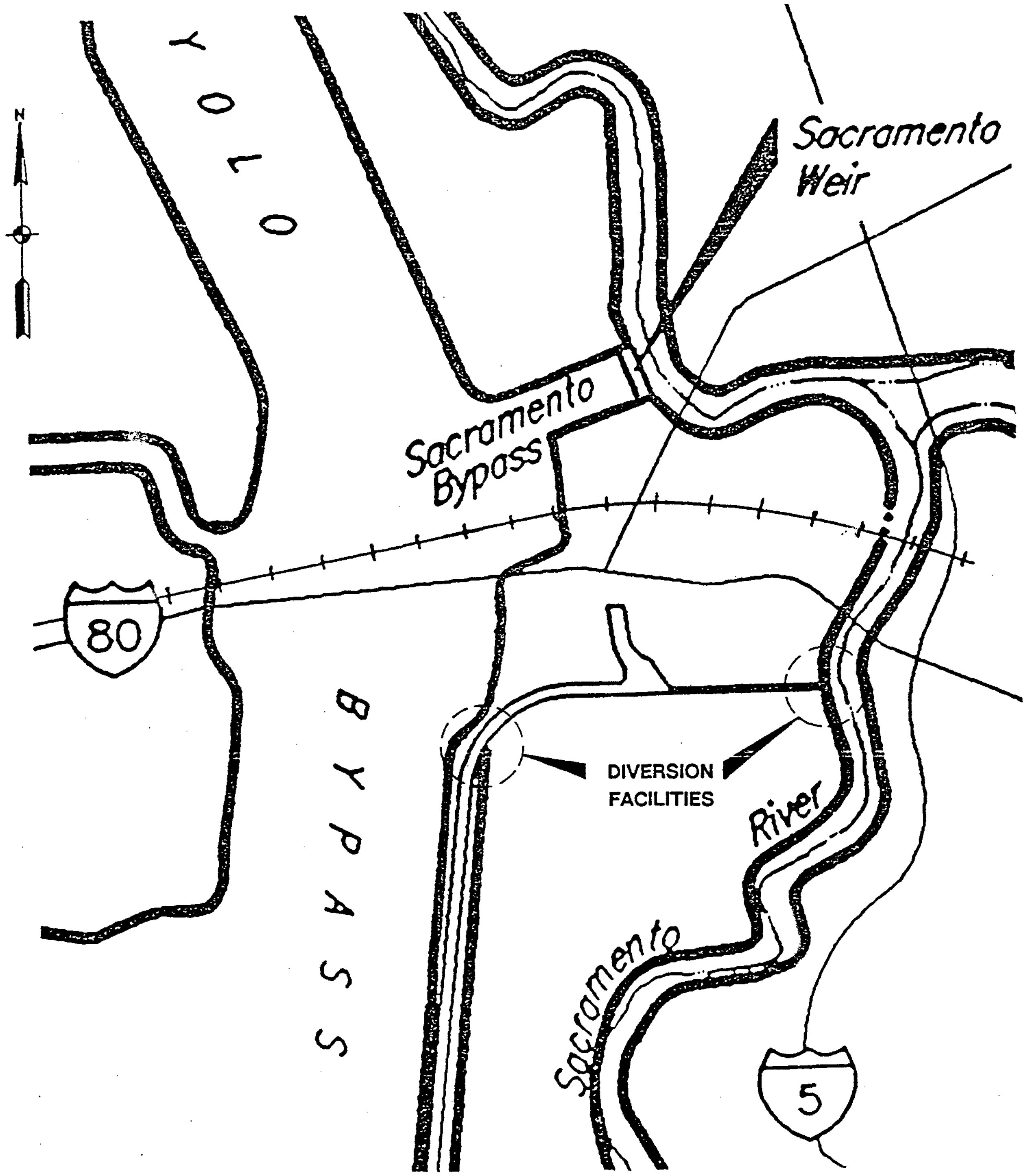
SACRAMENTO METROPOLITAN AREA
CALIFORNIA

MODIFY SACRAMENTO WEIR AND BYPASS

NOT TO SCALE

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1989

FIGURE 2



NOT TO SCALE

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

DIVERT FLOODWATERS INTO THE SACRAMENTO RIVER DEEP WATER SHIP CHANNEL

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1989

FIGURE 3

Modify Levees Around West Sacramento

This measure consists of raising portions of the levees around the city of West Sacramento to increase the level of flood protection to that area. Both 100-year and 200-year levels of flood protection were analyzed (Figures 4 and 5). Approximately 91,000 linear feet of levee would need to be raised for the 100-year level of protection and 118,000 linear feet for the 200-year level of protection. Design levee crown elevations were based on existing levee crown elevations, preliminary 100- and 200-year water surface profiles, and design freeboard criteria. Proposed levee raising on the west side of the Yolo Bypass and north side of the Sacramento Bypass would be included as potential mitigation for adverse flood impacts due to levee raising around West Sacramento. All raising and widening would be landward.

Remove Flow Constrictions from Yolo Bypass

This measure consists of replacing highway and railroad embankments with bridge structures to improve flow conveyance and reduce flood stages in the area of the Yolo Bypass adjacent to West Sacramento (Figure 6). This would involve replacement of approximately 4,700 linear feet of embankment material from I-80 and 9,700 linear feet from SPRR. Work on both the I-80 and SPRR crossings would be accomplished by constructing a new permanent pile-supported section parallel and adjacent to the existing embankment portion, followed by removal of the existing embankment section. An alternative measure for the I-80 embankment sections is to place 96-inch-diameter concrete pipes spaced 12 feet on center through the embankment sections.

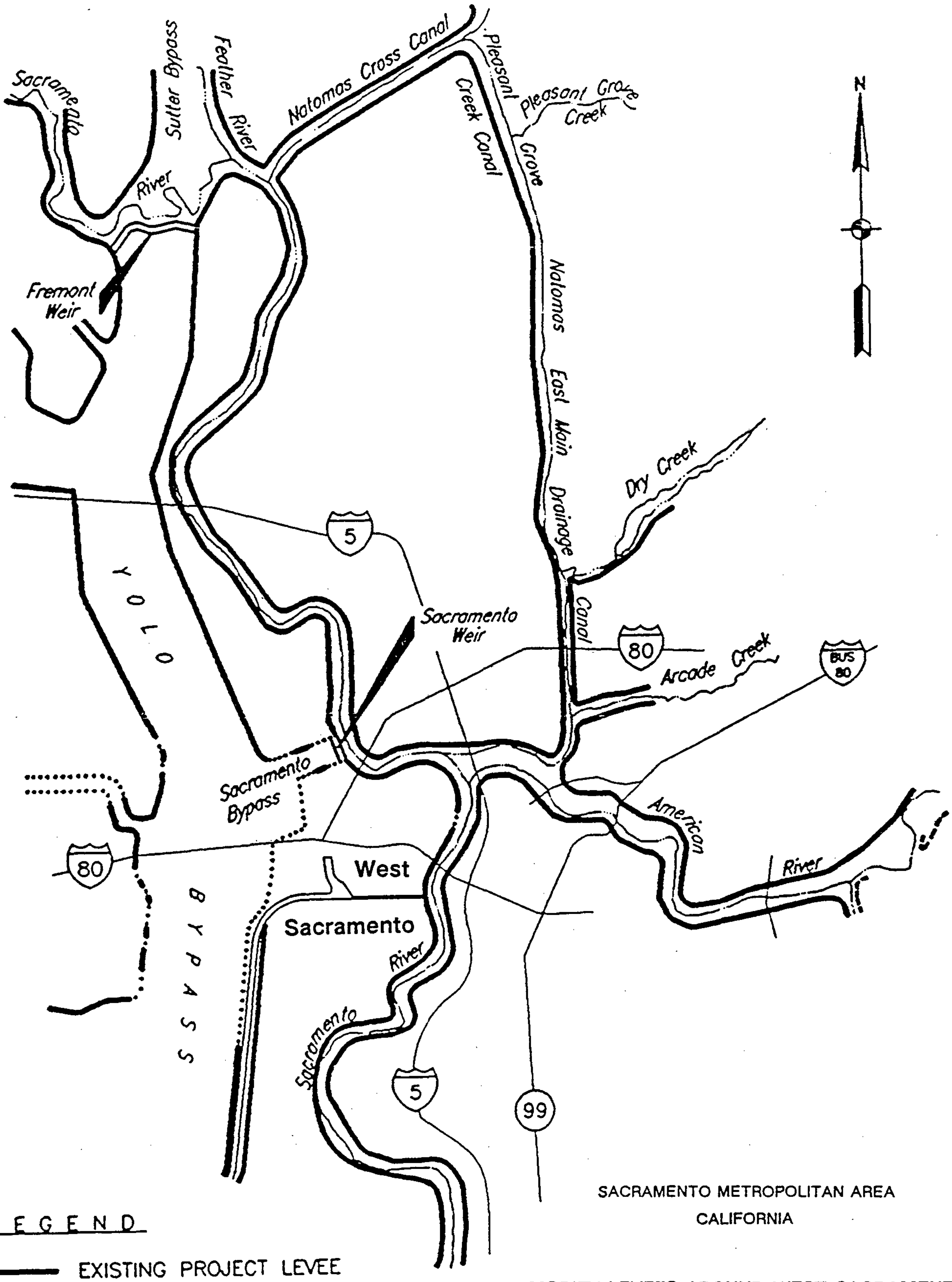
Combination

Any of the measures and options described above could be combined to develop a flood control plan for the study area.

COMPARISON OF MEASURES

Hydrologic Evaluation of Measures

In order to compare the hydrologic and hydraulic impacts of each measure, an unsteady flow model (DWOPER, dynamic wave operational model) was developed. The model was calibrated using hydrologic and hydraulic data from the 1983 and 1986 flood events and provides flow rates and water surface elevations at particular locations in the study area over the time interval considered. The model reasonably simulated the peak flows and peak water surface elevations of the 1983 and 1986 flood events, but model results used to evaluate these measures are considered of a reconnaissance level. The model has been refined in more detail in the evaluation of the final alternatives.



LEGEND

EXISTING PROJECT LEVEE

EXISTING PROJECT LEVEE TO BE RAISED FOR 100 YR. PROTECTION (91,000 L.F.)

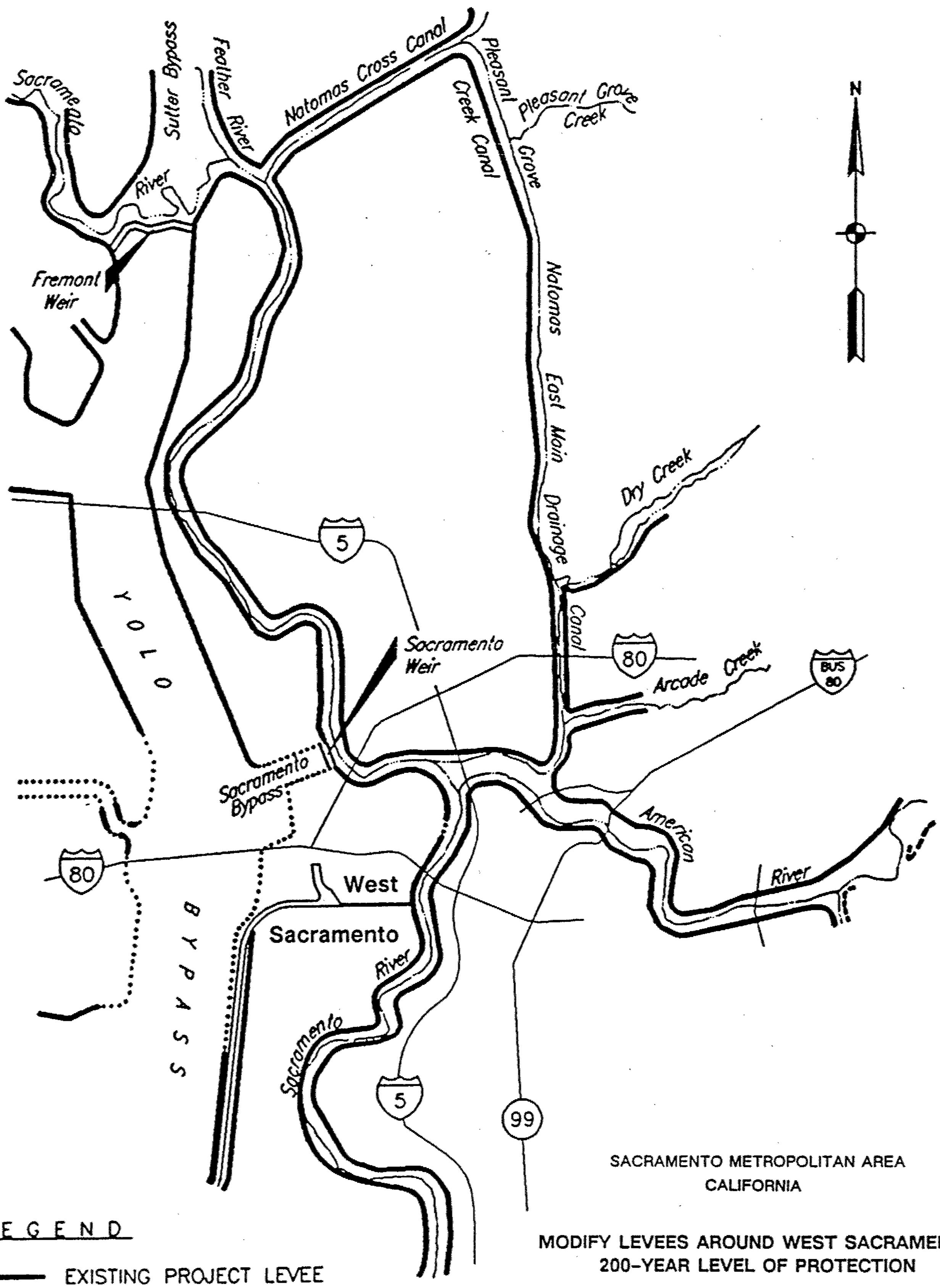
NOT TO SCALE

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

MODIFY LEVEES AROUND WEST SACRAMENTO
100-YEAR LEVEL OF PROTECTION

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1989

FIGURE 4



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

LEGEND

EXISTING PROJECT LEVEE

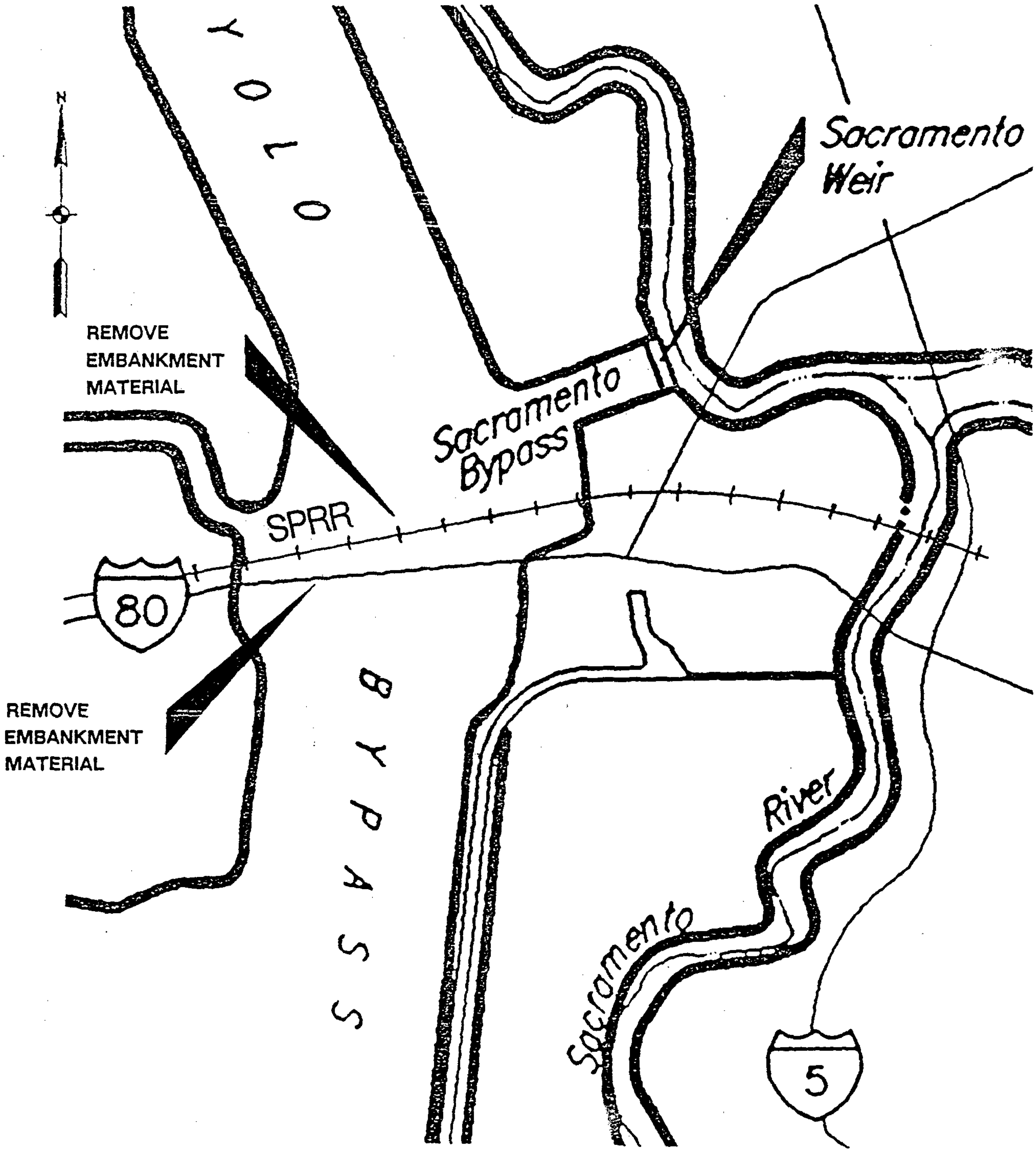
EXISTING PROJECT LEVEE TO BE RAISED FOR 200 YR. PROTECTION (118,000 L.F.)

NOT TO SCALE

MODIFY LEVEES AROUND WEST SACRAMENTO 200-YEAR LEVEL OF PROTECTION

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1989

FIGURE 5



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

REMOVE FLOW CONSTRICTIONS FROM YOLO BYPASS

NOT TO SCALE

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1989

FIGURE 6

Because the model was calibrated on the 1983 and 1986 flood events, modifications were necessary to incorporate the physical changes that have occurred in and adjacent to the study area since February 1986. With these modifications, the model generally represents physical conditions as of September 1988 and the without project condition for the comparison of flood control measures. (Some of the levee embankment modifications and sediment removal programs being considered by local entities for implementation in the future could modify the model simulations for the without project condition.)

For the with project condition, various physical parameters were modified in the existing model to simulate the various flood control measures. For this comparison, the American River Watershed investigation Selected Plan is not considered a with project condition. A comparison of model results under with and without project conditions was based primarily on differences in peak water surface elevations and flows within the study area.

Modify Fremont Weir and Yolo Bypass. - Preliminary hydrologic and hydraulic modeling efforts indicated that removal of deposited material upstream and downstream of the weir would be effective in reducing flood stages in the Sacramento River between the confluence with the Feather River and the Sacramento Bypass. (Although the Natomas Cross Canal is not included in the study area, it should be noted that reducing the flood stages in the Sacramento River would also reduce the flood stages in the Natomas Cross Canal.) Flood stages for the expected 100-year flood event or an event similar to the 1986 flood event could be reduced between 0.1 and 0.5 foot in this river reach, depending on location, if the land surface both upstream and downstream of the weir is reduced and maintained at 30.4 feet. In addition, flood stages would be reduced by similar amounts in the Yolo Bypass in the immediate vicinity of the weir. Impacts to flood stages throughout the remainder of the study area would be minimal and suggest that the system tends to revert to existing conditions (without project conditions) at and downstream of the Sacramento Bypass.

Widening the weir and the Yolo Bypass at the Fremont Weir up to 500 feet would not have a significant impact on flood stages in the study area based on preliminary analyses. Widening to 1,500 feet would have an impact on flood stages in the Sacramento River between the confluence with the Feather River and the Sacramento Bypass. For the 100-year flood event, flood stages in this river reach could be reduced between 0.1 and 0.5 foot, depending on location. Impacts to flood stages throughout the remainder of the study area would be minimal.

Lowering the existing weir crest about 1.0 foot and maintaining the land surface elevation both upstream and downstream of the weir at 29.4 feet by removing material could also reduce flood stages in the Sacramento River between the

Feather River and the Sacramento Bypass. With this plan, the observed 1986 water surface elevation of the Sacramento River near Verona would be reduced about 1.5 feet. Small increases in water surface elevation would result in the Yolo Bypass.

In general, the preliminary hydrologic and hydraulic modeling efforts indicated that the proposed modifications to the Fremont Weir and the Yolo Bypass (near the weir) would reduce flood stages significantly for major flood events in the Sacramento River between the Feather River and the Sacramento Bypass, in the Yolo Bypass near the weir, and in the Natomas Cross Canal. Flood stages throughout the remainder of the study area would not change significantly because (1) the maximum additional flow expected over the Fremont Weir for a 100-year flood event is about 20,000 cfs and (2) the flow system tends to revert to the without project condition at and downstream of the Sacramento Bypass. (An additional 20,000 cfs in the Yolo Bypass downstream of the Fremont Weir is equivalent to about 0.2 to 0.3 foot during major flood events.)

Modify Sacramento Weir and Bypass. - Preliminary analyses suggested that removing the existing gates and forming a smooth concrete surface with a crest elevation of 21.2 feet would only have a minimal impact on peak flood stages for events similar to or larger than the February 1986 flood in the study area. Floodwaters would begin to move over the Fremont Weir when the flow in the Sacramento River at Verona is about 58,000 cfs. Without gates at the Sacramento Weir, floodwaters would also begin to move over this weir at a flow of about 58,000 cfs in the Sacramento River. (Water surface elevations in the Sacramento River at the Sacramento Weir are influenced by backwater conditions from the American River,tides, and other factors.) Because of this, removing the gates would not significantly change the duration of flooding within the Yolo Bypass, but would change the flow regime during the time period that floodwaters are present in the bypass.

Preliminary studies indicated that widening the weir and bypass and maintaining the existing gate operation would increase the peak flows over the weir and would reduce the peak flood stages in the Sacramento River downstream of the weir for major floods similar to or larger than the February 1986 flood event. Widening the weir and bypass by 500 feet and 1,500 feet could increase peak flows over the weir by 10,000 cfs and 20,000 cfs, respectively, for the 100-year flood event. Flood stages for the 100-year flood event in the Sacramento River downstream of the weir could be reduced by about 1.5 feet, depending on the distance from the weir. Increases in flood stages in the Yolo Bypass would be insignificant because 10,000 cfs to 20,000 cfs represents only a 0.1- to 0.2-foot change in water surface elevation for flood events equal to or greater than the 100-year flood event.

Lowering the weir crest and maintaining the same gate operation could have results similar to widening the weir and bypass. When the weir crest is lowered, the gate structures would have to be increased in height the same amount in order to maintain the same operation. Lowering the weir crest by 0.5 and 1.0 foot would increase peak flows over the weir by 5,000 cfs and 10,000 cfs, respectively, for the expected 100-year flood event.

Divert Floodwaters into the Sacramento River Deep Water Ship Channel. - The 100- and 200-year flood events in the Sacramento River system would probably result in flood stages of 16.0 feet and 16.4 feet, respectively, in the Ship Channel near the Port based on preliminary hydrologic analyses. A rating curve developed for the Ship Channel downstream of the Port indicates that a 1.0-foot increase in the water surface elevation at the Port for the 100-year or 200-year flood event would result in a hydraulic gradient sufficient to convey about 10,000 cfs downstream through the Ship Channel. Similarily, 2.0- and 4.0-foot increases in the water surface elevation at the Port would result in the conveyance of about 20,000 cfs and 35,000 cfs, respectively.

Average velocities in the Ship Channel for a flow of 70,000 cfs would be 3 to 4 fps although localized velocities might be as high as 10 fps. For a flow of 40,000 cfs, average velocities would be 2 to 3 fps. Localized scour of the channel banks would occur during periods of peak flow although sediment deposition would dominate throughout the length of the Ship Channel for the duration in which floodwaters are diverted from the Sacramento River and/or Yolo Bypass.

Preliminary modeling efforts indicated that significant reductions in flood stages for major flood events similar to the 1986 flood event or larger could be achieved in the Sacramento River downstream of the American River by diverting excess floodwaters from the Sacramento River into the barge canal at the location of the lock. Diversions considered ranged between 20,000 cfs and 40,000 cfs. Diverting similar flows into the Ship Channel from the Yolo Bypass only had a minimal impact on flood stages in the study area for major flood events.

Modify Levees Around West Sacramento. - Based on preliminary data, the estimated level of flood protection for the city of West Sacramento is about a 90-year flood event*. Actual levee failures may occur at higher or lower recurrence intervals (flood stages) depending on flood duration, wave action, bank erosion, emergency efforts, etc. The 90-year level of flood protection assumes that the levee embankments are structurally stable and that any necessary structural repairs recommended under the "Sacramento River Flood Control System Evaluation," Corps of Engineers, May 1988, will be implemented prior to any improvements considered in this study.

*Based on more complete data, the level of flood protection is currently estimated to be about 70 years.

Raising and widening levee embankments around West Sacramento to provide design levels of flood protection for the 100-year, 200-year and larger flood events would reduce the probability of levee failure and overtopping. This reduction would have an adverse impact on flood stages at and downstream of those locations. Based on preliminary hydrology, a single levee breach on the Yolo Bypass side of West Sacramento could potentially occur during a 100-year flood event. Preventing this levee breach during the 100-year flood event would increase flood stages in the Yolo Bypass downstream of this location up to about 0.3 foot. For a 200-year flood event under existing conditions, more than one levee breach is probable, and preventing this occurrence could increase downstream flood stages up to about 0.5 foot.

Remove Flow Constrictions from Yolo Bypass. - Preliminary hydrologic and hydraulic modeling indicated that replacement of embankment material with bridge structures at both I-80 and the SPRR could reduce flood stages in the Yolo Bypass and the Sacramento Bypass adjacent to West Sacramento. For a major flood event, removal of the embankment material could reduce flood stages in the Yolo and Sacramento Bypasses upstream of I-80 and adjacent to West Sacramento between 0.5 and 1.0 foot. Reductions in flood stages in the Sacramento River and in the Yolo Bypass above Woodland are relatively insignificant.

No downstream adverse flood impacts are associated with removal of the embankment material. Because of the increased flow area possible at both I-80 and the SPRR, peak flow velocities and scour potential would also be reduced in the vicinity of the bridge structures.

Environmental Effects

Costs of potential mitigation measures were based on similar mitigation plans developed for projects and other studies in or adjacent to the Sacramento River watershed. Costs are considered as reconnaissance level and have been developed to estimate the total costs of various measures. For several measures, environmental costs are significant and impact the economic viability of the potential flood control measures.

Modify Fremont Weir and Yolo Bypass. - Flood control measures that include widening the Yolo Bypass near the Fremont Weir (by moving about 3 to 4 miles of the east levee embankment located just downstream of the weir either 500 or 1,500 feet back) could cause significant impacts to riparian vegetation. An adjacent irrigation canal (Tule Canal) parallels this section of the levee embankment on the waterward side of Yolo Bypass, and this canal supports significant areas of riparian vegetation and marsh habitat.

Removing this section of the existing levee embankment and hauling the material to the proposed alignment would be accomplished from the land side of the levee and would minimize any work in or immediately adjacent to the canal. Assurances from local landowners and the local sponsor would be required to prevent filling in and moving the existing canal toward the new alignment in the future to minimize adverse environmental impacts. Even with these conditions, about 60 acres of riparian vegetation, including emergent marsh, riparian forest and riparian scrub, could still be disturbed.

Based on cost estimates from "Wildcat and San Pablo Creeks," U.S. Army Corps of Engineers, August 1988, the cost to replace similar habitat values is estimated to be $18,000 per acre. This would include planting near the canal and maintaining the plantings for three seasons. The total cost of this mitigation plan is estimated at $1 million.

Lowering the existing weir crest by 1.0 foot could increase the duration of floodflows in the Yolo Bypass by 1 to 4 days per flood event. Increased flow durations could cause damage to oak trees in the bypass, but the magnitude of the change is so small that the effects are probably minor.

Sediment removal that would be required in conjunction with this measure would impact up to 200 acres of land area just upstream and downstream of the weir. Sediment removal plans would be similar to work recently accomplished by the State. Selective clearing of this area would be accomplished by avoiding areas of mature riparian vegetation. This would limit impacts to riparian scrub/shrub. The current estimate to revegetate this area based on the State's program is about $450 per acre for seeding. Total cost of this mitigation alternative is $100,000, which includes the cost of an airplane equipped to seed from the air.

Increasing the volume of water that passes over the Fremont Weir would increase the number of fish carried into the Yolo Bypass at this location. This impact could be offset by reductions in the volume of water passing through the Sacramento Bypass due to implementation of this measure. Whether or not this measure would result in additional fish being stranded in the Yolo Bypass as floodwaters recede is not known. Since there is insufficient information to determine if an adverse condition would result, no mitigation costs have been included in this evaluation. If adverse impacts are identified, potential mitigation measures could include increasing the number of fish released by hatcheries in the Sacramento River or enhancing spawning and rearing habitats along the river.

Direct construction impacts to aquatic resources could result from land surface depressions created by construction activities. Mitigation would require construction areas graded with a slope towards the Tule Canal.

Modify Sacramento Weir and Bypass. - Flood control measures that consider widening the Sacramento Bypass and the Sacramento Weir could damage riparian vegetation because of construction activities. Because of significant development on the landward side of the south levee of the Sacramento Bypass, widening alternatives considered setting back the north levee (and extending the weir to the north).

An irrigation canal is adjacent and parallel to a portion of the north levee on the waterward side of the Sacramento Bypass. Removing the existing north levee embankment and hauling the material to the proposed alignment would be accomplished from the land side of the levee and would minimize any work in or immediately adjacent to the canal. In addition, the weir would be extended to the new levee alignment. Even with the above conditions, about 2 acres of riparian forest could be impacted. Required mitigation would include revegetation of about 3 acres, at a total cost of about $60,000.

Removing the existing gates and forming a smooth concrete surface with a crest elevation at 21.2 feet (no widening) would not significantly change the duration of flooding within the Yolo and Sacramento Bypasses, but would change the flow regime during the time period that floodwaters are present in the bypasses. Environmental impacts to vegetation from this option are considered minor.

Lowering the weir crest by 0.5 foot and 1.0 foot (no widening) and maintaining the existing gate operation would increase the duration and volume of floodwater diverted through the Sacramento Bypass. Sediment removal either upstream or downstream of the weir is not proposed with this option. If sediment removal is needed, riparian vegetation in the toe drains waterward of the bypass levees could be avoided to minimize impacts.

Widening the weir and bypass would increase the volume of floodwaters diverted into the Sacramento Bypass. Lowering the weir crest would not only increase the volume of floodwater diverted into the bypass but would also increase the duration in which floodwaters are diverted. The increase in volume and/or duration of floodwaters diverted into the bypass system would probably result in additional fish being stranded in the Yolo Bypass as floodwaters recede. The magnitude of this impact has not been estimated. Although potential costs have not been determined, mitigation alternatives could include increasing the number of fish released by hatcheries in the Sacramento and American Rivers or enhancing spawning and rearing habitats along the river.

Direct construction impacts to fish under this measure could result from land surface depressions created by construction activities. Mitigation would require construction areas graded with a slope towards the Tule Canal.

Divert Floodwaters into the Sacramento River Deep Water Ship Channel. - Terrestrial impacts of this measure would be minor. Construction of new levees and associated relocations of existing facilities around the Port would require reseeding of levee embankments and other construction areas for erosion control.

Water would be diverted through the Ship Channel in one of two methods: by using a siphon with a pump or by constructing overflow weirs. Fisheries impacts associated with these methods would be minimal. Diverting water through a siphon would require a pump to initiate the flow. The gravity flow of the siphon would divert water without the continuous use of pumps. Any impact would be limited to the initial action to begin the flows. The use of overflow weirs to divert floodwaters would also have a minimal impact on fisheries.

Modify Levees Around West Sacramento. - Levee embankment modifications required in this measure would be accomplished by raising and widening levee sections to the landward side only. In addition, construction activities would be limited primarily to the top and the landward side of the existing levee embankment.

Preliminary evaluations indicated that levee embankment modifications would be required on the Sacramento River, Sacramento Bypass and both sides of the Yolo Bypass west of the city of West Sacramento. Construction activities could impact between 10 and 15 acres of riparian forest and emergent marsh, depending on the design level of flood protection. Costs of potential mitigation alternatives, primarily revegetation, range between $100,000 and $150,000. No work is considered necessary for the cross levee at the southern boundary of West Sacramento.

Remove Flow Constrictions from Yolo Bypass. - Construction and clearing activities involved in removing all of the embankment material (replacing with bridge or culvert structures) from I-80 and the SPRR on the Yolo Bypass would impact about 25 acres of riparian scrub. Environmental impacts associated with localized decreases in flood stages and peak velocities are considered insignificant.

The estimated cost to mitigate for the loss of riparian scrub is $200,000. Mitigation measures could include revegetation of constructed and cleared areas and revegetation of other nearby land areas that could be acquired in fee or easement.

Construction Costs

Reconnaissance level construction cost estimates for the flood control measures are discussed in this section. First costs are based on October 1988 price levels. Annual costs are based on an 8-5/8 percent interest rate and a 50-year amortization period. The annual cost of operation and maintenance is included in the estimated annual costs. All costs assume that the levee embankments of the Sacramento River Flood Control Project system are structurally stable at the existing design water surface elevation.

Modify Fremont Weir and Yolo Bypass. - This measure involves various modifications to Fremont Weir and its existing operation. Each option would increase the peak flow and divert more water over the weir than under the without plan condition. The annual cost of each option includes a cost of $65,000 for monitoring sediment deposition near the weir, removing and disposing future deposited material, and acquiring land necessary for disposal of material. The monitoring program consists of setting up transect lines perpendicular to the weir, spaced approximately 1,000 feet apart, and surveying ground elevations in the summer months during those years in which the floodwaters reached the weir.

Assurances would be required from local interests to maintain the existing flow conveyance within the Sacramento River channel downstream of Fremont Weir. Although this channel reach was degrading under prior conditions, a monitoring and maintenance program would still be required to ensure that channel aggradation, if it does occur, would not adversely impact design levels of flood protection for the alternatives.

Sediment removal in conjunction with the flood control measures would require the acquisition of about 100 to 200 acres of land outside, but adjacent to the Yolo Bypass, for disposal. If purchased in fee, the land costs would be about $400,000. This cost could be less if excavated material is used to enlarge adjacent levee embankments, thereby minimizing land acquisition requirements.

Since the February 1986 flood event, the State of California has removed soil material just upstream and just downstream of the weir. In 1986, the State removed about 500,000 cy of sediments from the west side of the weir and disposed of the material outside of Yolo Bypass at a cost of about $650,000. (A local landowner permitted disposal of material on his property without the added cost of land acquisition.) In 1987, the State removed about 800,000 cy of sediments adjacent to the middle section of the weir at a cost of about $1 million. This material was disposed of at a central location in the Yolo Bypass just downstream of the weir. (The disposal material was stacked to minimize flow obstruction.) The State has plans to remove an

additional 650,000 cy of material from the east side of the bypass adjacent to the weir in the future, but the work depends on funding. In 1988 and 1989, State funding was not available. The material removed from this area of the weir could be disposed of by enlarging sections of the levee embankment on both the east levee of the Yolo Bypass and the west levee of the Sacramento River near the weir. To date, the State's sediment removal program has involved the removal of material down to an elevation about 1 to 2 feet lower than the crest elevation of the weir as shown in Figure 19. Localized areas of sediment aggradation near the trees were not excavated.

For purposes of comparison of the flood control measures, it is assumed that it is unlikely that additional material will be removed by the State because funds have not been approved for that purpose. In addition, since the weir was generally functioning as designed during the February 1986 flood event and prior to any sediment removal, future sediment removal by the State is not considered necessary maintenance to ensure the weir operation. As a result, the cost to remove additional material has been evaluated as a potential measure under this investigation.

Based on the sediment removal work performed by the State to date, about 200,000 cy of additional material would need to be removed to ensure that land surface elevations both upstream and downstream of the weir are generally no higher than the existing weir crest elevation of 30.4 feet. The estimated cost of sediment removal is about $250,000.

In addition, 35 existing flowage easements in the Sacramento and Yolo Bypasses were reviewed. Of these easements, none have limits on the depth or duration of flooding. Assuming these 35 easements are representative of all flowage easements in the Sacramento and Yolo Bypasses, increased depth and duration of flooding would not require modifications to existing easements or additional compensation to landowners. (The bulk of the existing flowage easements provide for "a perpetual right and easement, without recourse to compensation for damage therefrom, past, present or future, for the passage of all waters of the Yolo Bypass which may from time to time inundate or which has heretofore inundated the lands of the grantors over, upon and across all of the following described lands....").

No project levee exists on the west side of the Yolo Bypass downstream of the confluence with Putah Creek. In this area, flowage easements were obtained to the outer limits of flooding under design flow conditions (at the design water surface elevation). If peak flow conditions in this area were increased over design conditions, then additional flowage easements would be required because the extent of flooding would be increased.

As discussed in the section on the "Hydrologic Evaluation of Measures," proposed modifications to the Fremont Weir and the Yolo Bypass (near the weir) would not have a significant impact on flood stages in the study area downstream of the Sacramento Bypass. As a result, no additional flowage easements are required in the Yolo Bypass area south of Putah Creek.

Widening the weir either 500 or 1,500 feet involves setting back the east levee of the Yolo Bypass to increase the flow capacity of the bypass. The east levee was selected because this would allow better alignment with the inlet of the Yolo Bypass with the outlet of the Sutter Bypass. The length of setback levee would be approximately 3 miles (see Figure 1). This measure also includes extending the weir either 500 or 1,500 feet. The design of the weir extension would be the same as the current design.

Based on the evaluation of existing flowage easements and peak flood stages downstream of Putah Creek, no additional flowage easements or compensation would be needed for lands within the Sacramento and Yolo Bypasses for the options described. There is a concern that increased flows and durations will adversely affect local drainage within the various tributaries (Knights Landing Ridge Cut, Willow Slough, etc.) to the Yolo Bypass.

Construction costs for the various options are summarized below:

Option		First Cost($)	Annual Cost($) 1/
1		650,000	120,000
2			
	500 ft	9,000,000	840,000
	1,500 ft	13,400,000	1,220,000
3			
	0.5 ft	1,470,000	190,000
	1.0 ft	2,035,000	240,000

1/ Annual cost includes a cost of $65,000 for monitoring sediment deposition near the weir and removing and disposing of future deposited material.

Modify Sacramento Weir and Bypass. - This measure includes various modifications to the Sacramento Weir and its existing operation. Most of the options would increase the peak flow and divert more water over the weir than under the without project condition.

Removing the existing gates and forming a smooth concrete surface with a crest elevation of 21.2 feet has only a minimal impact on peak flood stages similar to or larger than the February 1986 flood event in the study area. (See section on "Hydrologic Evaluation of Measures.") During the 100-year (and greater) flood event, all 48 gates would be open during the

rising limb of the flood hydrograph. In addition, all gates would be open for 3 or more days until peak flood stages are attained in the study area. Because of the operation time when all gates are open, peak flood stages attained with this alternative (no gates) would be similar to peak flood stages with the existing system. Since peak flood stages with or without this alternative are similar, no additional flowage easements are required for the Yolo Bypass. (See the discussion in the section "Modify Fremont Weir and Yolo Bypass, Construction Costs.") The first cost and annual costs for this alternative are $85,000 and $10,000, respectively. (Because peak flood stages attained in the study area with or without the gates are similar, no reduction in flood damages has been attributed to this option. It is possible, however, that a permanent structure without gates would reduce the possibility of operational problems given the labor-intensive requirements of manually opening each of the 48 gates.)

Widening the weir and bypass and maintaining the existing gate operation would increase the peak flows over the weir for major flood events similar to or larger than the February 1986 flood event. Increases in peak flows could increase flood stages in the Yolo Bypass downstream of the Sacramento Bypass by 0.1 to 0.2 foot for flood events equal to or greater than the 100-year flood event. The higher stages would require additional flowage easements in the Yolo Bypass downstream of Putah Creek because of the increase in flooded areas. The costs of the additional flowage easements are not included in this estimate but are considered small in comparison to the first cost of widening the bypass. The north levee of the bypass was set back because land north of the bypass is unimproved, whereas the California Highway Patrol Academy is located just to the south of the bypass.

This option also includes extending the weir, and the design of the weir extension will match the existing design. The problems with extending the weir are significant and costly. The UPRR crosses over the weir and must remain open for traffic between Sacramento and Woodland, a city west of the Yolo Bypass. This could be accomplished by building a temporary bypass track, trucking the commodities or rerouting the traffic over another rail line. (The SPRR has indicated that they would probably not grant trackage rights in the area.) Vehicular traffic also crosses over the weir and would have to be diverted or rerouted. First cost and annual costs for widening the bypass by 500 feet (see Figure 2) are $7,200,000 and $640,000, respectively. Widening the bypass by 1,500 feet would have a first cost of $14,900,000 and annual costs of $1,320,000.

Lowering the weir crest and maintaining the same gate operation (no widening of the bypass) would have results similar to widening the weir and bypass. When the weir crest is lowered, the height of the gate structures would have to be increased the same amount in order to maintain the same operation. As in the case of widening the weir and bypass, additional flowage

easements on Yolo Bypass downstream of Putah Creek would be required. The cost of these easements is not included in this estimate. Existing land surface elevations just upstream and downstream of the weir crest are lower than the proposed weir crest elevations being considered. As a result, lowering the weir crest either 0.5 or 1.0 foot would not require removing sediment material just upstream or downstream of the weir. First cost and annual costs for lowering the weir crest elevation by 0.5 foot are $1,500,000 and $130,000, respectively. First cost and annual costs for lowering the weir crest elevation 1.0 foot are $1,750,000 and $160,000, respectively.

One of the operational objectives of the Sacramento and Fremont Weirs is to maintain flows in the Sacramento River to prevent depositional build-up. Any change in the physical configuration or operation of the Sacramento and Fremont Weirs could impact that operational objective. With any proposed changes to the weirs, assurances would be required from local interests to maintain existing flow conveyance within the Sacramento River channel. A monitoring and maintenance program would need to be developed to ensure that channel aggradation would not occur in the Sacramento River channel.

Divert Floodwaters into the Sacramento River Deep Water Ship Channel. - This measure would divert a portion of the floodwaters in the Yolo Bypass and/or the Sacramento River into the Ship Channel near the Port by pumps and bypasses. Based on information in the section "Hydrologic Evaluation of Measures," diverting flows of 20,000 to 40,000 cfs into the Ship Channel from the Yolo Bypass side would have only a minimal impact on flood stages in the study area for major flood events. As a result, diversion from the Yolo Bypass side was deleted from further consideration.

Preliminary hydrologic modeling efforts did indicate that significant reductions in flood stages for major flood events (similar to the 1986 flood event or larger) could be achieved in the Sacramento River downstream of the American River by diverting excess floodwaters from the Sacramento River into the barge canal via the lock. The costs and problems associated with this diversion are significant. Major Port facilities, such as docks, loading cranes, warehouses, etc., would have to be relocated and/or reconstructed because new levees would be required on both sides of the Ship Channel adjacent to the Port. During those periods when floodwaters were diverted into the Ship Channel, ship traffic would be impacted. In fact, ship movement would probably cease. In addition, changes in erosion and deposition in the channel would probably increase dredging costs significantly. Because of these costs and problems, the Sacramento-Yolo Port District (who owns and operates the Port of Sacramento) does not support using the Ship Channel as a diversion channel for floodwaters. Because of the increased costs, potential problems and local opposition, the alternative was deleted from further consideration.

Modify Levees Around West Sacramento. - This measure involves raising and widening sections of levee to achieve 100- and 200-year levels of flood protection. Construction activities would be limited primarily to the top and landward side of the existing levee embankment.

The design freeboard criterion for both the Yolo and Sacramento Bypasses is 6 feet. The Sacramento River and other streams require 3 feet. On Willow Slough Bypass, there is also a transition reach where the freeboard changes from 6 to 3 feet. Using local stage-frequency curves, high water mark profiles from the 1986 flood event, wind-set criteria and other information, the 100- and 200-year water surface profiles were estimated for preliminary design purposes. These profiles, along with levee crown surveys and freeboard criteria, were used to determine whether the levee embankments would need to be increased in height in order to provide a specific level of flood protection. In order to compensate for any adverse flood impacts, levee embankment modifications were also made to levees on the west side of the Yolo Bypass and on the north side of the Sacramento Bypass (see Figures 4 and 5).

Preliminary first costs and annual costs for this measure are as follows:

Modify Levees Around West Sacramento
First and Annual Cost Estimates

Level of Flood Protection	First Cost	Annual Cost
100-year	$3,800,000	$340,000
200-year	$6,700,000	$590,000

These costs do not include costs needed to structurally modify the levee embankments to meet the design requirements under existing conditions. As presented in the "Sacramento River Flood Control System Evaluation," Corps of Engineers, May 1988, the cost to structurally repair the existing levees around West Sacramento is estimated at about $2,350,000. Structural repairs might also be needed when improving the levees on the west side of the Yolo Bypass and on the north side of the Sacramento Bypass. These structural repairs, if needed, are currently scheduled to be evaluated in a separate investigation.

Remove Flow Constrictions from Yolo Bypass. - This measure would consist of replacing highway and railroad embankment material with bridge or culvert structures at I-80 and the SPRR on the Yolo Bypass. The raised embankments reduce flow capacity when compared to pier-supported crossings.

The I-80 crossing over the Yolo Bypass consists of approximately 4,700 linear feet of raised embankment with the remainder being supported by piers. Average daily traffic is

85,000 vehicles with a peak of 100,000 vehicles. During the morning and evening commutes and during Friday and Sunday evenings, the system is near peak capacity. The California Department of Transportation (Caltrans) was consulted on the idea of removing the embankment portion of the I-80 crossing and replacing those sections with piers. Possible options included: (1) build a new permanent pile-supported section parallel and adjacent to the existing embankment portion and then remove the existing embankment section, and (2) build a temporary embankment section next to the existing embankment section, remove the existing embankment section, build a pile-supported section in its place, and then remove the temporary embankment section. All designs would have to satisfy Caltrans freeway standards for speeds of 65 miles per hour, and traffic flow could not be disrupted. Option (2) appears to be less costly with an estimated cost of $123 million.

The SPRR crossing consists of three raised embankment sections totaling 9,700 feet, with the remainder being supported by piers. Possible options include: (1) build a new permanent pile-supported structure with an alignment parallel to the existing line and then remove the existing railroad crossing, and (2) build a temporary elevated shoefly next to the existing line, remove the existing embankment section, build a pile-supported line in its place, and then remove the temporary shoefly. The SPRR line would have to stay open during construction since it is unlikely that trackage rights could be acquired from another railroad to reroute the traffic. Option (1) appears to be less costly with an estimated cost of $18 million.

The combined estimated costs for the removal of the embankment sections is about $140 million. Three to four construction seasons would probably be needed to complete the work.

During the meetings with Caltrans, another option was discussed. This option would consist of jacking concrete pipe through the embankment sections. Caltrans stated that this option would eliminate the need to reroute or delay traffic. They have jacked pipe through embankments in the past, but on a smaller scale. Using 96-inch-diameter pipes, spaced at 12 feet on center, the flow capacity through the pipes would be approximately 30 percent of the capacity that would be achieved by removing the embankment sections. The estimated cost of this option would be $245 million.

Benefit Evaluation

Preliminary flood damage reduction benefits were based on a comparison of existing and with project condition levels of flood protection in the study area. Estimates of the recurrence intervals at which levee failures could potentially occur under existing conditions were based on levee performance during the February 1986 flood event, expected flood durations, wave action

(including wave erosion), bank erosion, the ability of local entities to install floodgates at predetermined locations, magnitude and location of minimum freeboard and stage-frequency curves developed in the reconnaissance phase of this study. For West Sacramento, the preliminary estimate of the existing level of flood protection was about a 90-year flood event on the Sacramento River side, the Sacramento Bypass side and the Yolo Bypass side of the city (assuming the levee embankments are structurally modified to meet existing design requirements). Minimum freeboard for a 90-year flood event is about 1.6 feet on the Sacramento River near "I" Street, about 2.8 feet on the Sacramento Bypass near the Yolo Bypass levee and about 2.2 feet on the Yolo Bypass. For the Elkhorn area the existing level of flood protection was estimated to be about a 75-year flood event on the Yolo Bypass and the Sacramento River sides.

The Flood Insurance Administration of FEMA has recently reevaluated the flood hazard potential for the West Sacramento and surrounding areas. Based on reconnaissance level hydrology and the structural evaluation of the levee embankment system ("Sacramento River Flood Control System Evaluation," Corps of Engineers, May 1988), West Sacramento and the Elkhorn area do not have 100-year levels of flood protection. Because of the uncertainty of future development in these areas, no future growth was considered in the reconnaissance phase of this study. ER 1105-2-40, 2.4.11(b), "Economic Considerations," July 9, 1983, specifies that future growth considerations are not required if the benefit-to-cost ratio is above unity and if cost sharing is not affected. Future growth scenarios are considered in the Economics Appendix (Appendix A).

Based on preliminary analyses, the average annual damages under without project conditions for West Sacramento were about $12 million (assuming no future growth and that structural repairs are implemented). For the Elkhorn area (under the same assumptions) the average annual damages under without project conditions are estimated to be about $200,000.

Modify Fremont Weir and Yolo Bypass. - Based on existing conditions, about 200,000 cy of additional material would be removed to ensure that land surface elevations both upstream and downstream of the weir are generally no higher than the weir crest elevation of 30.4 feet. With this option, flood stages for the 100-year flood event or an event similar to the 1986 flood event could be reduced between 0.1 and 0.5 foot in the Sacramento River between the confluence with the Feather River and the Sacramento Bypass. The most significant reductions in flood stages would occur near Verona and the Natomas Cross Canal. The reduction in flood stages for the 100-year flood event near the Natomas Cross Canal would also reduce the flood hazard in the Natomas area. The flood control benefits to the Natomas area could easily exceed $2 million on an annual basis. In addition, this option could also increase the level of flood protection to

the Elkhorn area along the Sacramento River. Total average annual benefits attributable to this option is in excess of $2 million.

Widening the Fremont Weir and Yolo Bypass near the weir by 500 feet does not have a significant impact on flood stages in the study area. Widening the Fremont Weir and Yolo Bypass by 1,500 feet has impacts similar to those indicated for the sediment removal option and would result in average annual benefits in excess of $2 million.

Lowering the weir crest about 1.0 foot and removing about 600,000 cy of material near the weir to ensure that land surface elevations both upstream and downstream of the weir are generally no higher than 29.4 feet would reduce flood stages near Verona on the Sacramento River by about 1.5 feet. Average annual benefits would be in excess of $2 million.

In general, the options available for modifying the Fremont Weir and Yolo Bypass near the weir are economically feasible based on preliminary analyses and provide a cost effective approach to providing higher levels of flood protection to the Natomas area. In addition, the options can also increase the level of flood protection and reduce the amount of levee work that would be needed to achieve higher levels of flood protection for the Elkhorn area, assuming that the levee embankments around the Elkhorn area are structurally stable at existing design conditions.

Modify Sacramento Weir and Bypass. - Removing the existing gates and forming a smooth concrete surface with a weir crest elevation of 21.2 feet would not impact peak flood stages in the study area for flood events similar to or larger than the February 1986 flood event. Since peak flood stages that could result in levee failure are similar with or without the gates, no reduction in flood damages has been attributed to this option. It is possible, though, that an ungated overflow structure could reduce the risk that might be associated with manually opening each of the gates. Since manual operation requires a field crew and radio and telephone communication for instructions, there is always the possibility that something could go wrong during flood periods. Benefits that might be attributed to reduced risk because of an ungated structure have not been quantified. In addition, an ungated structure would reduce maintenance and operation costs and could reduce the amount of levee improvements required under other flood control alternatives.

Widening the weir and bypass and maintaining the existing gate operation would increase the peak flows over the weir and reduce peak flood stages in the Sacramento River downstream of the weir for major floods similar to or larger than the February 1986 flood event. Even though peak flood stages are reduced in Sacramento River adjacent to south Sacramento (including the Greenhaven area), the level of flood protection would probably

not change significantly for that area. Preliminary analyses on the existing levels of flood protection for south Sacramento (from the Sacramento river side) indicated a 200-year flood level or greater. Since peak flood stages are not expected to increase substantially over those indicated for the 200-year event, flood damage reduction benefits attributable to the south Sacramento area were considered insignificant. In addition, adverse flood impacts (although small) resulting from increased flow in Sacramento Bypass and Yolo Bypass would be mitigated to maintain existing levels of flood protection. Since the existing level of flood protection for the West Sacramento area on the Sacramento Bypass and Yolo Bypass sides would be maintained (to meet mitigation requirements), no benefit would result from this option for West Sacramento.

Lowering the weir crest and maintaining the same gate operation would have results similar to widening the weir and bypass. Benefits attributable to this option would also be small.

Divert Floodwaters into the Sacramento River Deep Water Ship Channel. - Based on reconnaissance level evaluations, the costs of this flood control measure exceed potential benefits. Because of this and local opposition to the alternative, the alternative was deleted from further consideration.

Modify Levees Around West Sacramento. - Based on preliminary analyses the estimated level of flood protection for West Sacramento is about a 90-year flood event. Actual levee failures may occur at higher or lower recurrence intervals (flood stages), depending on flood duration, wave action, bank erosion, emergency efforts, etc. The 90-year level of flood protection assumes that the levee embankments are structurally stable and that any necessary structural repairs recommended in the "Sacramento River Flood Control System Evaluation," Corps of Engineers, May 1988, will be implemented prior to any improvements in this study. (Structural repairs estimated for the levees around West Sacramento cost between $2 and $3 million.)

Raising and widening levee embankments around West Sacramento to provide design levels of flood protection for the 100-year and 200-year flood events would reduce potential flood damages to West Sacramento and the Port. In accordance with planning guidance for determining flood damage prevention benefits in the freeboard range, benefits are claimed for one-half of the area under the frequency-damage curve between the design level of protection and the largest flood that might be carried within the freeboard.

Based on preliminary analyses, the estimated flood damages in West Sacramento from the 100-year and 200-year flood events (under existing conditions) are $850 million and $1.2 billion, respectively. Average annual damages under without project conditions are about $12 million based on an existing 90-year

level of flood protection. Under with project conditions for 100-year and 200-year design levels, average annual benefits would be about $6.5 and $9 million, respectively.

Remove Flow Constrictions from Yolo Bypass. - Replacing highway and railroad embankment material with bridge or culvert structures at I-80 and the SPRR on the Yolo Bypass would reduce flood stages in the Yolo and Sacramento Bypasses adjacent to West Sacramento. For a major flood event, removal of the embankment material could reduce flood stages in the Yolo and Sacramento Bypasses upstream of I-80 and adjacent to West Sacramento between 0.5 and 1.0 foot. Reductions in flood stages in the Sacramento River and the Yolo Bypass above Woodland are relatively insignificant.

A preliminary estimate of average annual damages for the West Sacramento area under without project conditions are about $12 million (assuming an existing 90-year level of flood protection, significant wave action and no flood fighting efforts). The combined estimated construction costs for the removal of the embankment sections is about $140 million. Any benefits attributable to the reduction in flood stages is not significant enough to justify the high costs associated with embankment removal. (No significant change in the level of flood protection would occur on the Sacramento River side of West Sacramento.)

Summary

Information developed during the reconnaissance level evaluation of the benefits and costs of the various flood control measures is presented in Table 1. These measures have been evaluated based on a 50-year project life (1995-2045), 8-5/8 percent discount rate and 1988 price levels.

Two of the measures considered, diverting floodwaters into the Ship Channel and removing flow constrictions from the Yolo Bypass (I-80 and the SPRR embankments), have very high costs and potential adverse impacts. The high cost for using the Ship Channel as a temporary flood control channel results from the need for new levees on both sides of the channel adjacent to the Port and associated relocation and reconstruction of major Port facilities, such as docks, loading cranes, warehouses, etc. The high cost involved in the removal of embankment material from I-80 results from Caltrans' concern and need to avoid traffic disruption on the interstate highway system. In addition, the Sacramento-Yolo Port District, who owns and operates the Port of Sacramento, does not support using the Ship Channel as a diversion channel for floodwaters because of potential impacts to ship traffic.

Modification of the Sacramento Weir and Bypass would have only a minimal impact on reducing potential flood damages. Removing the existing gates and forming a smooth concrete surface with a crest elevation of 21.2 feet would have no significant

impact on peak flood stages similar to or larger than the February 1986 flood event in the study area. Widening the weir and bypass or lowering the weir crest would increase peak flows over the weir and would decrease peak flood stages in the Sacramento River downstream of the weir. Adverse flood impacts (although small) attributed to increased flow in the Sacramento Bypass and Yolo Bypass would be mitigated to maintain existing levels of flood protection. Existing levels of flood protection along the Sacramento River downstream of the Sacramento Bypass (on the south Sacramento side) were estimated to be greater than the 200-year flood event based on preliminary studies. Since peak flood stages are not expected to increase substantially over those indicated for the 200-year event, flood damage reduction benefits attributable to the south Sacramento area were considered insignificant. Also, since the existing level of flood protection for the West Sacramento area on the Sacramento Bypass and Yolo Bypass sides would not change, no benefit would result from this option for West Sacramento.

As indicated in Table 1, the flood control measures that were economically feasible include modifications to the Fremont Weir and Yolo Bypass and levee improvements for the city of West Sacramento. Most options considered for the Fremont Weir and vicinity have a benefit-to-cost ratio of 1.5 and greater. All options would result in small increases in water surface elevation (because of increased flow over the weir) in the Yolo Bypass between the Fremont Weir and Sacramento Bypass for major flood events. These adverse flood impacts would be mitigated to maintain existing levels of flood protection adjacent to the Yolo Bypass. Flood control benefits attributable to the Fremont Weir options are primarily in the Natomas area because of reduced peak flood stages in the Sacramento River near the Natomas Cross Canal. For the West Sacramento area, 100-year and 200-year preliminary design levels of flood protection (attained by raising existing levees) result in about $6.5 and $9 million in average annual benefits and benefit-to-cost ratios of 18.5 to 1 and 15 to 1, respectively.

TABLE 1

ECONOMIC SUMMARY OF FLOOD CONTROL MEASURES 1/
(1988 Price Level, 8-5/8% discount Rate, 1995-2045 Project Life, $1,000)

Flood control Alternatives 2/	First Cost Construction	First Cost Environmental	Annual Cost 3/	Annual Benefit	B/C Ratio
Modify Fremont Weir and Yolo Bypass					
Remove material	650	100	130	2,000 4/	15.4+
Widen 500 feet	9,000	1,000	925	minimal	--
Widen 1,500 feet	13,400	1,000	1,305	2,000 4/	1.5+
Lower weir 0.5 feet	1,470	100	200	2,000 4/	10+
Lower weir 1.0 feet	2,035	100	250	2,000 4/	8+
Modify Sacramento Weir and Bypass					
Remove existing gates	85	--	10	minimal 5/	--
Widen 500 feet	7,200	60	645	minimal	--
Widen 1,500 feet	14,900	60	1,325	minimal	--
Lower weir 0.5 feet	1,500	--	130	minimal 5/	--
Lower weir 1.0 feet	1,750	--	160	minimal 5/	--
Divert Floodwaters into the Sacramento River Deep Water Ship Channel	Preliminary evaluations indicate costs significantly greater than benefits				
Modify Levees around West Sacramento					
100-year plan	3,800	100	350	6,500	18.5
200-year plan	6,700	150	610	9,000	15
Remove Flow Constrictions from Yolo Bypass I-80 and the SPRR	141,000	200	12,500	significantly less than annual cost	--

1/ All values estimated from reconnaissance level data and are preliminary in nature.
2/ Assumes levees are structurally stable under existing design conditions.
3/ Includes monitoring, maintenance and environmental costs.
4/ Estimate of annual benefits are in excess of $2 million and are primarily attributable to the Natomas area.
5/ Benefits attributable to an ungated overflow structure have not been evaluated in sufficient detail other than for flood damage reduction benefits. Benefits attributable to reduced risk (elimination of the manual operation), reduced maintenance and operation costs and reduced amounts of levee improvements associated with other flood control alternatives have not been quantified. Because of the low cost of these options, a detailed benefit evaluation could indicate the options are economically feasible.

SACRAMENTO METROPOLITAN AREA, CALIFORNIA

FEASIBILITY REPORT

APPENDIX C

HYDROLOGY OFFICE REPORT

OFFICE REPORT

SACRAMENTO METRO INVESTIGATION, CALIFORNIA

ADDENDUM TO JANUARY 1990 AMERICAN RIVER AND SACRAMENTO METRO INVESTIGATIONS REPORT

HYDROLOGY

US Army Corps of Engineers
Sacramento District

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF CHARTS

LIST OF CHARTS

CHAPTER I - INTRODUCTION

1. **AUTHORITY** - This study was conducted under the authority of the Flood Control Act of 1962 (Public Law 87-874, dated October 23, 1962) as follows:

   "The Secretary of the Army is hereby authorized and directed to cause surveys for flood control and allied purposes, including channel and major drainage improvements, and floods aggravated by or due to wind or tidal effects, to be made under the direction of the Chief of Engineers, in drainage areas of the United States and its territorial possessions, which include the following named localities: Sacramento River Basin and streams in Northern California draining into the Pacific Ocean for purposes of developing, where feasible, multi-purpose water resource projects, particularly those which would be eligible under the provisions of title III of Public Law 85-5001."

2. **PURPOSE AND SCOPE** - The main purpose of this study is to determine the current level of protection provided by the Sacramento River Flood Control System around West Sacramento. This determination became necessary after the large flood event of February 1986 heavily taxed the system. The 1986 flood produced higher flows and stages at some locations within the Flood Control System than any flood since the 1862 flood. This flood was extreme despite the construction of many upstream dams and flood control structures in the years since 1862.

   After this event, the American River and Sacramento Metro investigations were initiated. This report will focus on the Sacramento Metro study. This report can be considered as an addendum to the American River report since it will present data developed subsequent to the American River report. Results of the American River study can be found in the report entitled, "American River and Sacramento Metro Investigations, California" and dated January 1990. The American River report will be referenced throughout this report.

   The Sacramento Metro study required detailed hydrologic input to answer many questions which arose during and after the February 1986 event. To answer these questions, Planning Division coordinated various work order requests with Hydrology Section. Listed below are main job items contained in these work order requests.

   Compare the 1986 event to design flows and stages.
   (see Table 3, page 8 and Charts 44 to 46)

   Compute the 100-, 200- and 400-year flood volumes at Fremont Weir
   (see Chart 13)

   Compute the 100-, 200- and 400-year stages at various locations.
   (see Charts 34 thru 43 and Tables 17 to 23, pages 50-56)

Compare the 1986 peak stages with the 100-year stages at various locations.
(see Tables 17 to 22, pages 50-55)

Develop Flow-Frequency curves for the American River
(see Chapter III, Section 2 and Charts 6 and 7)

Determine the effects of increased storage capacity on the American River.
(see Tables 17 to 22, pages 50-55)

Determine the sensitivity of possiblity levee failures.
(see Tables 17 to 23, pages 50-56)

Determine the effects of removing the boards at Sacramento Weir.
(see Table 22, page 55 and Charts 47 and 48)

The scope of Sacramento Metro study is confined to the West Sacramento area. This includes the Yolo Bypass, Sacramento Bypass and the Sacramento River below the Sacramento Weir. Although the scope is limited, events over a large geographical area determine the amount of flow in the West Sacramento area. Over 23,000 square miles of drainage exists in the Sacramento River basin above West Sacramento. Therefore, to study the West Sacramento area, it was necessary to determine the contribution of the entire Sacramento River basin. This report will discuss the development of assumptions and computer models for the entire basin and show how various conditions in the basin effect the West Sacramento area. The American River report also looked at the entire Sacramento River basin as well as the American River above Folsom. The American River above Folsom will not be discussed in this report

This report will provide the above listed data, along with necessary supporting data, in the form of text, tables and charts. Chapter II presents basic descriptive hydrology of the study area. Included in this description are: topography, soils, vegetation, climate, the Sacramento River Flood Control System (SRFCS), and a discussion of general basin flood and flow characteristics. Chapter III looks at the hydrologic analysis of the study area for both the 1986 event and synthetic events. This chapter includes the development of volume-frequency curves for both the Sacramento and American Rivers. Chapter IV looks at the hydraulic analysis of the study area using the DWOPER (Dynamic Wave Operational Model) computer program. Chapter V discusses the development of the stage-frequency curves. Chapter VI discusses possible modifications of the Sacramento Weir. Chapter VII lokks at wave runup calculations for the Yolo Bypass.

3. <u>COMPUTER PROGRAMS</u> - Due to many flow and stage complexities, it was necessary to use two computer programs to successfully model the study area. Rainfall runoff was computed using the HEC-1 Flood Hydrograph

Package. This package was used where backwater effects are not a problem. In areas of major backwater influence, negative head differences (ie: upstream flow) and stage caused weir flow, the DWOPER (Dynamic Wave Operational Model) computer program was used. This program, developed by the Hydrologic Research Lab branch of the National Weather Service, is designed to be used in areas where backwater effects are troublesome for routing methods used in HEC-1 and HEC-2 (Water-Surface Profiles). DWOPER also affords the user the luxury of combining flow and stage hydrographs in order to test concurrencies and incorporate the influences which stage and flow have on each other, something that can be a problem when using HEC-2.

A. HEC-1 Model - The areas listed below were modeled with HEC-1.

RIVER	AREA
Sacramento River System	Above Fremont Weir
Feather River	Above Bear River
Natomas Cross Canal	Above Pleasant Grove Canal
American River	Above Folsom
Natomas East Main Drain	Arcade Creek
	Dry Creek
	Local above Dry Creek (Elverta drainage)

B. DWOPER MODEL - The reaches listed below were modeled with DWOPER.

RIVER	REACH
Sacramento River	Tisdale Weir to Courtland
Sutter Bypass	Tisdale Weir to Fremont Weir
Yolo Bypass	Fremont Weir to Lisbon
Feather River	Bear River to Sacramento River
Natomas Cross Canal	Pleasant Grove Canal to Sacramento River
American River	Nimbus to Sacramento River
Natomas East Main Drain	Sankey Road to American River

CHAPTER II - DESCRIPTIVE HYDROLOGY

1. BASIN DESCRIPTION -

A. GENERAL - The Sacramento River basin at the I-Street bridge drains approximately 23,500 sq mi. The General Map, Chart 1, shows the central portion of the Sacramento River Basin. The basin extends from near the Oregon border on the north, the peaks of the Sierras on the east, and the Coast Ranges on the west. Some of the main contributing rivers and creeks to the Sacramento River are the Feather and American Rivers and Cottonwood Creek. Flows on the American are controlled by Folsom Dam. Flows on the Feather are partially controlled by Oroville Dam. Some uncontrolled flows enter the Feather River below Oroville Dam. Cottonwood Creek is uncontrolled. Other uncontrolled flows enter the Sacramento River as it flows in a southerly direction from Shasta Dam to Sacramento.

B. TOPOGRAPHY - Topography of the basin varies from flat valley areas and low rolling foothills, to steep mountainous terrain. Elevations in the Sacramento Basin below Shasta and above Red Bluff range from about 280 feet to near 8,000 feet in the upper reaches of Cottonwood Creek. In this reach, the main stem of the Sacramento River has a slope of about 5 ft/mi. In the reach from Red Bluff to Ord Ferry, elevations range from less than 100 feet at Ord Ferry to near 10,000 feet at the top of Mt. Lassen. Approximately 50% of the area is below 1,000 feet. The average slope of the Sacramento River is about 1 ft/mi. Below Ord Ferry and above Fremont Weir, elevations range from below 100 feet to near 3,000 feet in the Coast Ranges. The slope of the Sacramento River is less than 1 ft/mi. Below Fremont weir, the Sacramento River is fed by the Feather and American Rivers. The elevations in the Feather and American Rivers range from about 100 feet to near 10,000 feet in the upper reaches of the Sierra.

C. SOILS - Soil cover in the Sacramento River Basin is moderately deep with classifications varying from sands, silts and clays in the valley areas to porous volcanic area in the northern end of the basin. In the American and Feather River Basins, the soils range from granitic rock in the upper elevations to alluvial deposits in the valley areas.

D. VEGETATION - Vegetation in the higher elevations of the study area is dominated by coniferous forest. The foothills and valley areas are dominated by an oak-brush-grassland environment. Many valley areas in the Sacramento River Valley are cultivated.

2. CLIMATE

2. CLIMATE - The climate in the Sacramento River Basin is temperate and varies according to elevation. In the valley and foothill areas the summers are hot and dry and the winters cool and moist. At the higher elevations the summers are warm and slightly moist and the winters are cold and wet.

A. **TEMPERATURES** - Average annual temperatures in the Sacramento River Basin range from the middle 60's in the valley areas to the low 50's at the higher elevations. Temperatures range from nearly 120 degrees in the northern valley to below zero in the Sierra Nevadas. Average monthly temperatures for the National Weather Service's Downtown Sacramento location are shown on Table 1.

TABLE 1
NATIONAL WEATHER SERIVCE - DOWNTOWN SACRAMENTO STATION AVERAGE MONTHLY TEMPERATURES

MONTH	MAXIMUM °F	MINIMUM°F
January	53.9	40.2
February	60.6	43.7
March	65.4	45.2
April	71.9	48.2
May	79.7	52.8
June	87.1	57.3
July	93.1	60.0
August	91.5	59.6
September	87.6	58.1
October	78.0	52.6
November	64.1	45.3
December	54.6	40.4
Yearly	74.0	54.3

B. **PRECIPITATION** - Normal annual precipitation (NAP) varies widely throughout the basin, ranging from the low teens in valley areas to over 70 inches in some mountain areas. NAP maps can be found on Charts 2, 3, and 4. Normal monthly precipitation totals for Sacramento (#11 on Chart 3), Red Bluff (#8 on Chart 2), and Georgetown Ranger Station(#58 on Chart 4) are shown on Table 2.

TABLE 2
AVERAGE MONTHLY PRECIPITATION (inches)

MONTH	SACRAMENTO	RED BLUFF	GEORGETOWN RS
January	4.18	4.50	11.36
February	2.94	3.31	7.72
March	2.18	2.39	7.06
April	1.44	1.51	4.79
May	0.35	0.77	1.77
June	0.13	0.43	0.57
July	0.05	0.06	0.23
August	0.09	0.10	0.28
September	0.30	0.46	0.68
October	0.90	1.16	2.88
November	2.31	3.10	6.24
December	3.00	3.59	9.35
Annual	17.87	21.38	52.93

3. **EXISTING WATER RESOURCES PROJECTS** - There are many existing projects in the study area. A description of many of these projects can be found in the report entitled "Sacramento Metropolitan Area, California, Reconnaissance Report", Dated February 1989.

4. **SACRAMENTO RIVER FLOOD CONTROL SYSTEM** - The Sacramento River Flood Control Project, shown on Chart 3, was authorized by the Flood Control Act of 1917. The project consisted of putting levees along the major rivers, to handle the small flood flows, and constructing a levee bypass system to handle large floods.

The flood control project was designed on the basis that 600,000 cfs passing Rio Vista constitutes a very rare flow and the upstream flows that contribute to the 600,000 cfs were also rare events. The project's levees, weirs and bypasses are shown below.

LEVEED REACHES

RIVER	REACH
Sacramento	Ord Ferry to San Francisco Bay
Feather	City of Oroville to Sacramento River
American	Mayhew Drain to Sacramento River

WEIRS	BYPASSES
Moulton	Sutter
Colusa	Yolo
Tisdale	Sacramento
Fremont	
Sacramento	

Also included were numerous levees to control backwater from the River and Bypass system.

Storms from the Pacific track through the Sacramento River Basin, of which the Feather and American Rivers are tributaries, in many different ways. The System intercepts the runoff and moves it, without being life threatening, to the San Francisco Bay. Flood waters coming down the Sacramento River flow over the Tisdale Weir first, the Colusa Weir second, Fremont Weir third, Moulton Weir fourth, and the Sacramento Weir last. Tisdale, Colusa, and Moulton Weirs overflows enter into the Sutter Bypass, which dumps its waters into the Yolo Bypass, over Fremont Weir, and the Sacramento River at the Feather River mouth. Fremont Weir water goes into the Yolo Bypass, which empties back in to the Sacramento River near Rio Vista. The Sacramento Weir water flows through the Sacramento Bypass into the Yolo Bypass. The Feather River flood flows comingle with the Sutter Bypass flood waters upstream of the Feather River mouth. American River flood flows enter into the Sacramento River and flow both downstream and upstream. Upstream flows enter the Yolo Bypass via the Sacramento Weir and Sacramento Bypass. The levee crown elevations were originally established using water surface profiles that complemented the design flows (that made up the 600,000 cfs) and an estimated freeboard to handle the wind waves. The level of protection that the levees provide is an unknown. Because of the 1986 flood, studies are being conducted to determine the level of protection that all the levees in this system provide.

Since the original project was authorized, many reservoir projects have been constructed to control the runoff into the Sacramento River system. Some of these major projects are shown below.

RESERVOIR	YEAR BUILT	FLOOD CONTROL SPACE (ac-ft)	STREAM
Shasta	1945	1,300,000	Sacramento
Oroville	1967	750,000	Feather
Folsom	1956	400,000	American
New Bullards Bar	1966	170,000	Yuba
Black Butte	1963	137,000	Stony

Historical floods have tested this system many times, but none stressed the system like the February 1986 flood. In many areas the design flows were exceeded.

The Sacramento flood control system stages are sensitive to all flows and levee failures within the system. The stages in the area of Fremont Weir are dependent upon how the flows occur in time and magnitude in the Sacramento, Feather, and American Rivers. In addition, historically, during major runoff events levee failures have helped to reduce downstream stages. Thus, if upstream levees are prevented from failing, there is a greater potential for higher stages than have occurred historically. During

the February 1986 flood event, the lower part of the system, from the mouth of the Feather River to below Rio Vista, experienced flows which surpassed previous records. Table 3 lists a comparison of 1986 flows and stages to design flows and stages.

TABLE 3

COMPARISON OF DESIGN FLOWS AND STAGES
AND
PEAK FLOWS AND STAGES DURING FEBRUARY 1986 FLOOD EVENT

Location	Chart 1 Location Number	Design Flow (cfs)	February 1986 Peak Flow (cfs)	Design Stage (msl)	February 1986 Peak Stage (msl)
Sacramento River at Verona	34	107,000	92,900	38.2	39.11
Sacramento River Fremont Weir Spill	39	343,000	341,000	37.8	38.54
Yolo Bypass near Woodland	40	377,000	374,000	31.3	31.46
Yolo Bypass near Lisbon	49	490,000	495,000 to 509,000 (estimated)	23.2	24.88
Sacramento River Sacramento Weir Spill	42	112,000	127,680	31.5	30.56
Sacramento River at I-Street	45	110,000	115,000	31.1	30.58
Sacramento River at Freeport	48	110,000	117,000	25.4	25.11
American River at H-Street	44	115,000 152,000	134,000	40.0 42.0	40.4

5. **GENERAL BASIN FLOOD CHARACTERISTICS** - Major flood producing storms over Northern and Central California are generally associated with storm systems which originate in the Gulf of Alaska and develop a warm, moist air inflow from about the latitude of Hawaii. This combination results in moist unstable air. As the air mass encounters the north-south Coast Range it is orographically lifted (lifting caused by a mountain range). This lifting causes a cooling of the air mass. As the air cools, its ability to hold water is reduced. Therefore, the water which cannot be retained aloft is released as rain or snow. This is the basic recipe that caused the February 1986 flood event.

   Adding to the natural storm and flood complexities are the reservoir releases within the flood control system. Even though these reservoirs control rare events, their releases can also result in large flows. Since Mother Nature's wrath cannot be 100% predicted, times will come when large releases are necessary to make room for unforeseen inflows. In 1986, large flood flows in the American and Feather Rivers were a result of releases from Folsom and Oroville Dams, which were smaller than the inflows to these reservoirs.

6. **FLOW CHARACTERISTICS** - The flood control system exhibits many complex flow characteristics. Included in these complexities are weir diversions, upstream flows and mutual backwater effects at river junctions. Two of the more interesting locations are mentioned below.

   A. **Feather River** - During periods when the Feather River is experiencing high flows, as in 1986, the peak stage recorded at the Sacramento River at Verona gaging station (39.11 NGVD in 1986) is higher than the peak stage recorded at the Sacramento River at Fremont Weir West End station (38.56 NGVD in 1986) even though the West End station is approximately 5 miles upstream of Verona. Surface flows have been observed moving in the upstream direction, during several large floods.

   B. **American River** - During periods when the American River is experiencing high flows, as in 1986, the diversion effect of the Sacramento Weir will cause American River waters to merge with the Sacramento River waters and flow upstream in the Sacramento River, exiting over the Sacramento Weir into the Yolo Bypass.

CHAPTER III - HYDROLOGIC ANALYSIS

1. **GENERAL** - This chapter will discuss the development of: (1) the flow-frequency curves for the American River at Fair Oaks, and (2) the volume-frequency curves at the confluence of the Sacramento and Feather Rivers (SFRC). These analyses were used to develop the flow hydrographs used as input to DWOPER. Additional discussion on the American River can be found in the American River report.

2. **AMERICAN RIVER** -

A. FLOW-FREQUENCY ANALYSIS -

1. **Unregulated Conditions** - In 1961, a statistical analysis was done to estimate the likely frequency of occurrence for various flows in the American River at the Fair Oaks gage downstream from Folsom Dam. This analysis indicated that Folsom could control all flows up to the 120-year flood. However, because of the 1986 flood and since 5 of the 10 largest flows in the basin for 82 years have occurred since 1961, and 7 of 10 largest events have occurred since 1951, a new flow-frequency analysis was conducted. The first step in this re-analysis was to update the unregulated rainflood volume-frequency relationships at the Fair Oaks gage. These relationships reflect the flow data collected for the period 1905 to 1954 and adjusted flow data from 1955 to 1986. The adjusted flow accounts for the effects of French Meadows, Hell Hole, Loon Lake, Union Valley, and Ice House Reservoirs. Refer to the American River report for the locations of these reservoirs. This adjustment is necessary to provide a consistent record for statistical analysis.

   Updated rainflood volume-frequency curves are shown on Chart 6. They reflect 82 years of record (1905-1986) for unregulated conditions for the American River at the Fair Oaks gage, for 1-, 3-, 5-, 7-, 10-, 15-, and 30-day durations.

2. **Existing (Regulated) Conditions** - A revised peak flow frequency curve was developed for the American River at Fair Oaks. Estimated effects of storage in the reservoirs upstream in the basin were included in the derivation of the curve. The 31 years of actual recorded flow data since construction of the dam were used to define the plotting positions of flows more frequent than about the 50-year exceedence interval. To help define the plotting positions of flows less frequent than the 50-year event, hypothetical flood hydrographs were developed and routed through Folsom. The routing assumed currently applicable criteria, some of which has been updated from that used in the operation during the February 1986 flood. The resultant flow-frequency curve is shown on Chart 7.

The effects of the upstream reservoirs are shown on the 100-year hydrograph on Chart 8. The reduction in inflow to Folsom Lake due to storage in these reservoirs is evident in the rising limb of the 100-year hydrograph. A review of historical floods showed that about 47,000 ac-ft of effective upstream storage would be available "on the average" during major floods up through the 100-year frequency. No reductions in inflow to Folsom were made for floods larger than the 100-year. It was assumed that preceeding storms are sufficient to fill the upstream storage space. Only about 14 percent of the American River Basin lies above the upstream reservoirs.

The following assumptions were used in the reservoir routings for Folsom:

A. At the beginning of each hypothetical flood, Folsom was assumed to have an initial encroachment of 80,000 ac-ft in the flood control space with a concurrent outflow of 20,000 cfs. The encroachment was based on historical averages and to account for uncertainties in realtime operation. The outflow of 20,000 cfs is the assumed flood control release.

B. Releases from Folsom Dam were limited by outlet and spillway capacities. Releases below the spillway crest were made through the outlet works. An additional 7,000 cfs was released through the powerhouse.

C. Releases were made in conformance with the Flood Control and Emergency Release Diagrams currently in use. The Emergency Release Diagram governs releases greater than the design channel capacity.

3. **Folsom Reservoir Outflow Summary** - Table 4 summarizes Folsom Reservoir outflow flow-frequency relationships. It shows peak inflows and outflows for selected flood events. The table shows that Folsom can control all events up to the 63-year flood to outflows of 115,000 cfs or less. It also indicates that above the 200-year event, outflow will be approximately equal to inflow. Chart 9 shows a plot of the Standard Project inflow hydrograph.

TABLE 4

FOLSOM RESERVOIR OUTFLOW - FLOW FREQUENCY [1]

Flow-Frequency Return Period (yrs)	Peak Inflow (1000 cfs)	Peak Outflow (1000 cfs)
50	274	115
63	300	115
85	332	180
100	353	234
200	442	432
250 (SPF)	530	530
400	543	543
500	578	578

[1] Due to the failure of an upstream cofferdam, the February 1986 peak inflow was around 900,000 cfs. The peak outflow was 134,000 cfs.

3. SACRAMENTO RIVER -

A. GENERAL - The Sacramento-Feather River confluence (SFRC) is the combination point of over 21,000 square miles of drainage. Below this point, flood flows are split between the Sacramento River, which continues past the junction with the Natomas Cross Canal, and the Yolo Bypass. This study required the development of the 100-, 200-, and 400-year flood hydrographs and stages at the SFRC point in the Sacramento River Flood Control system under present hydrologic conditions. The peak flows from these three floods will be used to determine stages for these frequencies in the Sacramento River and Yolo Bypass at selected locations from the Sacramento-Feather River Confluence (SFRC) downstream to Lisbon on the Yolo Bypass and to Courtland on the Sacramento River. The following paragraphs describe (1) the flood characteristics and basin; (2) basin model selection and use; (3) the methods used to determine the flow volume frequency curves for SFRC; and (4) the derivation of the 100-, 200-, and 400-year floods.

B. FLOOD CHARACTERISTICS AND LOWER SACRAMENTO RIVER BASIN DESCRIPTION - Flood flows in the upper Sacramento River Basin below Shasta Dam are generally confined to their channels and their immediate overbank areas. After passing near Red Bluff and the Iron Canyon Ridge, the Sacramento River flows onto a broad alluvial plain flanked by the Butte and Colusa basins. Most of the tributary flows do not enter the Sacramento River directly but instead flow for considerable distance downstream through the Butte and Colusa basins before reaching the Sacramento River. See General Map, Chart 1. The Butte and Colusa basins have, in the past, received considerable overflow from the main river floods. The principal flood basins between Red Bluff and the SFRC are described in the following subparagraphs.

1. **Butte Basin** - Butte Basin is north of Sutter Buttes and south of the latitude of Ord Ferry. It has an area of 150 square miles and a detention-storage capacity of 700,000 acre feet at flood stages. It receives overflow water from Sacramento River over low banks near Ord Ferry (when the river is above 90,000 cfs); through the overflow weir at Moulton (when the river is above 60,000 cfs), and Colusa Weir (when the river is above 30,000 cfs); and has received overflow north of the Sutter Buttes from the Feather River prior to construction of levees along the west bank of Feather River. Butte Basin discharges pass through the Butte Slough outfall gates into the Sacramento River when the river is low, and into Sutter Bypass when the river is high.

2. **Sutter Basin** - Sutter Basin is south of Sutter Buttes. It has an area of 138 square miles and has a potential detention-storage capacity of 890,000 acre-feet when levee failures occur. Design capacity of the Sutter Bypass varies from 178,000 cfs below the Sutter Buttes to 216,000 cfs at its confluence with the Feather River.

3. **Colusa Trough** - Colusa Trough is on the west side of the Sacramento River, extending from south of Stony Creek to Cache Creek, and has a detention-storage capacity of 690,000 acre-feet. The eastern side of this basin has been partially reclaimed by levees and an interception ditch along the west side of these levees. The interception ditch discharges into Sacramento River through Knights Landing outfall gates when the river is low, or into the Yolo Bypass through Knights Landing Ridge Cut when the river is high. Flows in the Sacramento River at Ord Ferry would have to exceed 300,000 cfs before any water would spill into the Colusa Trough.

4. **Feather River Levees** - The levees along the Feather River and its tributaries from Oroville to Nicolaus protect about 530 square miles from flooding, with an estimated detention storage of over 600,000 acre-feet with levee failure. Design channel capacity on the Feather River varies from 210,000 cfs above the Yuba River to 320,000 cfs below the Bear River. The Yuba River, from the Feather River to about 8 miles upstream, has a channel capacity of 180,000 cfs when Feather River flows are low, and 120,000 cfs when Feather River flows are high.

The largest peak flows at the SFRC seem to be caused by storm centerings over the Feather River Basin. Since the 1930's, good flow records have been available on a continuous basis for most of the drainage area above the SFRC. The three largest storms during this period, February 1986, December 1964 and December 1955, were centered over the Feather River Basin.

C. **BASIN MODEL** - As previously discussed, the Sacramento River System below the latitude of Ord Ferry is very complex. Many flood control and channel projects have been completed in the basin during the last 60 years. The historic flow and stage data at the Sacramento-Feather River confluence reflect a variety of upstream regulation and levee improvements. To correctly analyze these regulations and improvements, it was necessary to adjust the historic flow record of the Sacramento River and its tributaries to present hydrologic conditions. This was to be accomplished using a routing model to route the larger historical flood flows through the reservoirs and the flood control system. Two routing models were tested: the NOAA River Forecast Center's RWT 70 model, and the HEC-1 model used for the Cottonwood GDM Report.

RWT 70 is a real time model used by the California Department of Water Resources and the Federal River Forecast Center to route flows through the Sacramento River Basin. The operation of this model was compared to the HEC-1 model of the flood system and was found to be more difficult to operate than the HEC-1. It is also inflexible when it comes to modeling possible levee failure scenarios.

The HEC-1 model was chosen for its flexibility and its ability to use different routing and diversion methods.

To simulate the movement of the flood flows through the flood control system, an HEC-1 model was set up to route the Sacramento River at Ord Ferry flood hydrograph into the upper Butte Basin, where it was combined with flows from Butte Creek and local areas. The combined flows were then routed, using a simulated reservoir routing, through the Sutter Bypass to Highway 162 and downstream to the Feather River. The Feather River hydrograph above the Yuba River was combined with the Yuba River hydrograph to produce the combined flow on the Feather River at Shanghai Bend. The flow at Shanghai Bend was combined with the flow from the Bear River and then routed to the Sutter Bypass and combined with the Sutter Bypass flows. This flow was routed to the Fremont Weir where it was combined with the Sacramento River before flowing over Fremont Weir. The routing diagram is shown on Chart 10.

The HEC-1 model was calibrated using the 1983 and 1986 floods. Reproductions are shown on Charts 11 and 12. These floods were used because the upstream basins reflected all of today's conditions with all present flood control features in operation.

All input hydrographs reflected present conditions, and were input into the model at:

A. Sacramento River at Ord Ferry

B. Butte Creek at Chico

C. Butte Basin Local

D. Feather River above the Yuba River (200- and 400-year floods only)

E. Yuba River above the mouth (200- and 400-year floods only)

F. Bear River at Wheatland

Output hydrographs were computed for the following locations:

A. Sacramento River-Feather River confluence

B. Sacramento River at Verona

C. Yolo Bypass below the Fremont Weir

D. VOLUME-FREQUENCY CURVES - The development of the 100-, 200-, and 400-year floods and stages required an understanding of what causes the high stages at the SFRC. A review of several large floods revealed that a large number of flow combinations from the Sutter Bypass, Sacramento River and Feather River can occur. Therefore, a volume-frequency relationship was developed at the SFRC, which reflects the many concurrent flows that have occurred historically. The 100-, 200-, and 400-year floods were calculated using this relationship.

Volume-Frequency Curves were developed for durations of 1-, 3-, 5-, 7-, 10-, and 15 days. These curves reflect today's conditions with all present flood control features in operation. They also reflect no levee failures until design flows have been exceeded. Design capacities of upstream project levees are shown in Table 5. Upstream flood control reservoirs are listed in Table 6. In order to compute the volume-frequency curves, the data must be as homogeneous, continuous and reliable as possible.

TABLE 5

DESIGN FLOWS ABOVE THE
SACRAMENTO-FEATHER RIVER CONFLUENCE

Location	Design Flows (in cfs)
Sacramento River Below	
Ord Ferry	90,000
Butte City	160,000
Moulton Weir	135,000
Colusa Weir	66,000
Tisdale Weir	30,000
Sutter Bypass	
Sutter Buttes to Tisdale Bypass	155,000
Tisdale Bypass to Feather River	180,000
Feather River to Fremont Weir	380,000
Feather River	
Above Yuba River	210,000
Below Yuba River	300,000
Below Bear River	320,000
Yuba River	120,000
Sacramento-Feather River Confluence	410,000

TABLE 6

UPSTREAM FLOOD CONTROL RESERVOIRS

Storage Facility	Year Start Storage	Total Capacity 1000 AF	Flood Control Space 1000 AF	Controlled Max. Release 1000 cfs	Downstream Protection
Shasta Res.	1943	4,552	1,300	79	100 year
Black Butte Res.	1963	160	137	15	60 year
Oroville Res.	1964	3,538	750	150	150 year
New Bullards Bar	1969	960	170	50	100 year

In order to have a homogeneous data set for developing the frequency curves, all flow data must reflect present physical conditions. Even

though many floods have occurred, it is extremely difficult to reconstruct all the flood hydrographs for the purposes of routing them through the present system.

The drainage area above the SFRC is very large, and many different rain flood centerings are possible. Using the largest floods that occurred during a continuous record, provides a good representation of many different centerings. Floods for the period 1929-1988 were selected because continuous records were not available for floods prior to 1929.

The eleven largest floods from 1929-1988 (59 years) were chosen to determine the volume frequency curve from the 6-year to the 100-year event. Historic hydrographs were developed to reflect routing effects of upstream flood control reservoirs. These hydrographs were routed, using the HEC-1 model, to the Sacramento-Feather River confluence to obtain peak and volume-duration flows at this point. Peaks and volumes for these floods are shown in Table 7.

TABLE 7

SACRAMENTO-FEATHER RIVER CONFLUENCE HISTORICAL FLOODS OF RECORD ADJUSTED TO PRESENT CONDITIONS

Flow in 1000 Mean Day-cfs

DATE	PEAK	1-DAY	3-DAY	5-DAY	7-DAY	10-DAY	15-DAY
Dec 1937	304.4	297.1	261.6	210.4	176.6	141.8	108.0
Feb 1940	322.4	308.9	286.1	252.6	220.2	190.6	161.4
Mar 1940	239.5	237.8	224.5	194.8	173.9	155.8	129.9
Jan 1942	260.5	257.6	248.8	226.3	207.1	182.0	172.7
Dec 1955	368.6	366.5	344.3	313.2	281.2	243.7	195.5
Feb 1958	254.0	251.0	241.8	220.6	208.6	199.5	164.4
Dec 1964	379.4	368.4	351.2	315.6	281.9	240.5	183.0
Jan 1970	308.4	304.4	291.9	276.2	265.3	252.5	229.7
Jan 1974	205.9	205.1	202.2	195.1	185.3	171.2	150.2
Feb 1983	281.7	278.6	264.1	246.4	229.3	211.4	205.6
Feb 1986	429.8	414.0	387.9	355.0	319.1	281.9	236.4

Since these are the 11 largest floods recorded in a continuous record of 59 years, the peaks and duration flow from these events were assigned mean plotting positions for that period and then plotted on log probability paper. A best fit linear curve was then calculated for each duration using Leo R. Beard's method for analytical frequency computation, omitting events more frequent than the 6-year event. The method is explained in "Statistical Methods in Hydrology," published by the U.S. Army Corps of Engineers, Sacramento District in 1962. The computed statistics and the flow-duration curves are shown on Chart 13.

Releases from the major upstream reservoirs are controlled for storm centerings somewhat rarer than a hundred-year event (see Table 6). At some point between the 100-year and 200-year events, these reservoirs can no longer store flood runoff and must increase releases. In order to develop the upper end of the frequency curves, the 200- and 400-year hypothetical floods were developed and routed. The hydrographs that were routed through the reservoirs and combined in the system were computed from full natural reservoir inflow duration-frequency curves. Centerings over the Feather-Yuba River basins were used to develop these larger floods at the SFRC. A detailed explanation on the development of the 400-year and 200-year flow-duration curves is given in paragraphs F and G.

For purposes of determining the amount of flow that will likely reach the SFRC the Feather and Yuba River levees upstream of the mouth of the Yuba River are allowed to fail when flows exceeded design capacity. The Feather River design flow above the Yuba River is 210,000 cfs. The Yuba River design flow is 120,000 cfs. However, in 1964, the Yuba River passed 180,000 cfs without encroaching into the freeboard. Flows greater than 120,000 cfs in the Yuba River are possible when flows in the Feather River are 120,000 cfs or less. The levee failures on the Feather and Yuba River were implemented according to the approved levee failure scenarios presented in the 1977 Marysville GDM; that is, for this study, the Yuba River levees failed when flows exceeded 120,000 cfs (concurrent Feather River flows were high) and the Feather River levees failed when flows exceeded 210,000 cfs. After the levee failure on the Yuba River, Yuba River flows downstream of the failure consisted of the remaining in-channel flows of 10,000 cfs plus 50% of the flows above 10,000 cfs. These flows were then added to flows of the Feather River at Shanghai Bend for the total flow of the Feather River at Shanghai Bend. An example of this is if the Yuba River had a flow of 170,000 cfs, 10,000 cfs would remain in channel, 50% of the remaining 160,000, cfs or 80,000, cfs would be added to the 10,000 cfs for a total flow of 90,000 cfs (eg. 10,000 cfs + .5*160,000 cfs = 90,000 cfs) that continued downstream to Shanghai Bend. This flow would then be added to the flows from the Feather River at Shanghai Bend. The same procedure was used for failures on the Feather River. After levee failures on the Feather River, Feather River flows consisted of in-channel flows of 50,000 cfs plus 50 percent of the flows above 50,000 cfs. These flows were combined with flows from the Yuba River at Shanghai Bend.

E. **100-YEAR FLOOD** - The 100-year flood was computed at the SFRC from the volume-frequency curves. Volume-mass curves were drawn for the 50- and 100-year flood events, along with the 1955, -64, -83, -86 events. These curves reflect the 1- through 15-day volumes. The 50- and 100-year mass curves were derived from the volume-frequency curves on Chart 13. The mass curve for the 100-year event was similar in shape to that for the 1986 flood. Therefore, for this study, the 100-year hydrographs were patterned after the 1986 flood hydrographs. The 100-year peaks and

volumes were obtained by increasing the 1986 flows to match the 100-year volume-duration data. The mass curves are shown on Chart 14. The 100-year hydrograph at SFRC is shown on Chart 15.

F. 400-YEAR FLOOD - There are two ways that a flood of the magnitude of a 400-year event could occur at the Sacramento-Feather River confluence (SFRC). The first is with a specific storm centered over the Sacramento River above Ord Ferry with a concurrent storm over the Feather River basin. Under this scenario, it is necessary for Shasta and Black Butte Reservoirs to release more than their objective flow (lose control). Very large flows would be experienced at Ord Ferry. However, peak and volume would be greatly reduced by the storage in the Colusa Trough and Butte Basin above the Sutter Buttes, and by levee failures in the Sutter Bypass above the Sacramento-Feather River confluence.

The second is with a specific storm centered over the upper Feather River basin with a concurrent storm over the Sacramento River Basin above Ord Ferry. Under this scenario, Shasta would not lose control but Black Butte, Oroville, and New Bullards Bar reservoirs would. Larger peaks would occur at the confluence because of the larger channel capacities and less overbank storage in the Feather River system. Historically, the largest flows have occurred at the SFRC when storm events are centered over the Feather River basin (as in 1955, 1964, and 1986). The largest flood flows at the mouth of the Feather River, for flood events greater than the 200-year event, would occur with centerings over the Feather River above the Yuba River.

Due to the complexity of trying to determine the synthetic storm centerings over the Feather and Sacramento Rivers, the 200-year and 400-year flood hydrographs at the SFRC were not computed using rainfall-runoff computations. The method used is described in the following paragraphs.

For this study, the 400-year event at the SFRC is based on an event having the greatest flow contribution from the Feather River. The 400-year, 15-day hydrograph for the Feather River above the Yuba River, and the Yuba River concurrent hydrograph, were patterened after the Standard Project Flood developed for the Feather and Yuba Rivers for the March 1977 Marysville Lake General Design Memorandum Phase I Plan Formulation Preliminary Report. All local Feather-Yuba flows were based on the 1986 event. Concurrent flow hydrographs at Ord Ferry (including controlled Shasta releases) for the 400-year event were developed using the 1986 event as a model. This was accomplished by dividing the 1986 maximum 10-day flow volume at Ord Ferry, by the 1986 10-day unregulated flow volume at Shanghai Bend. This is the ratio of the contributing local 10-day volume at Ord Ferry, to the total unregulated 10-day volume on the Feather River below the Yuba River (at Shanghai Bend) for the 1986 flood event. This ratio was then applied to the 400-year 10-day unregulated volume at Shanghai Bend, to find the corresponding 10-day

volume at Ord Ferry. As a result, the 1986 flows at Ord Ferry were increased by 54%. This made the concurrent flood on the Sacramento River at Ord Ferry a 20-year event. The peak flow for Ord Ferry plots at approximately a 20-year event. All local flows below Ord Ferry on the Sacramento River and below Shanghai Bend on the Feather River for the 400-year event were taken to be approximately the same as the 1986 local flows.

For the 400-year event, peak flows of 320,000 cfs occurred on the Feather River above Yuba River, and 257,000 cfs on the Yuba River at the mouth. For this study it was assumed these flows exceeded design capacities and caused failures on the Feather and Yuba rivers above their junction at Marysville. The Yuba River flows exceeded design capacity before the Feather River so the Yuba River levees failed first (concurrent flows in the Feather River were high). A short time later the Feather River levees above Marysville failed when its flows exceeded design capacity. After the levee failure on the Yuba River, Yuba River flows consisted of the remaining in-channel flows of 10,000 cfs plus 50% of the flows above 10,000 cfs. Flows from the Feather and Yuba Rivers were combined and routed to Shanghai Bend. The combined Shanghai Bend flows peaked at 330,000 cfs. The design capacity 300,000 was exceeded for only two hours. Because the peak was so sharp and flows above design capacity so brief the levees at or below Shanghai Bend were not failed. These flows at Shanghai Bend were then routed ináchannel to Nicolaus and combined with the Bear River flows. These flows were again routed to the Sacramento River and combined with Sacramento River flows at the Sacramento-Feather River confluence. All flows from the Sacramento River and Sutter Bypass remained within their respective design capacities. The total flow at the confluence has a peak of 507,000 cfs and a one-day volume of 503,000 cfs which exceeded its capacity of 410,000 cfs. The 400-year flood hydrograph is plotted on Chart 16 and the volume-duration curves are shown on Chart 13.

These volume-duration curves reflect in-channel flows above the SFRC. Flood volumes at the latitude of the SFRC which include water from upstream levee failures would probably be higher for events greater than the 100-year and for durations longer than one-day. All out of bank and overland flows due to levee failures continue downstream, paralleling their respective waterways and eventually join the Sacramento or Feather River or are stored behind downstream levees. These flows, moving at lower velocities than the main channel flows, will take weeks or even months to reenter their respective channels. These upstream levee failures will cause extensive interior flooding and may require pumping to remove the water from behind downstream levees.

G. **200-YEAR FLOOD** - The 200-year flood at the SFRC was modeled after the 400-year discussed above. These flows were routed through Oroville Reservoir on the Feather River and New Bullards Bar Reservoir on the Yuba River and combined at Shanghai Bend. All other concurrent flow

hydrographs for the Sacramento River and Feather River below Shanghai Bend were the same as were used in the 400-year routing.

During the 200-year flood, Shasta Reservoir did not lose control, but Black Butte, Oroville and New Bullards Bar did. Flows in the Feather River above the Yuba River peaked at 173,000 cfs, 23,000 cfs greater than the objective operation of Oroville Reservoir but lower than the 210,000 cfs channel capacity. Peak flows in the Yuba River reached 192,000 cfs. The left bank levees on the Yuba River failed when flows exceeded 120,000 cfs. After the levee failure on the Yuba River, Yuba River flows consisted of the remaining in-channel flows of 10,000 cfs plus 50% of the flows above 10,000 cfs. These flows were then added to flows of the Feather River at Shanghai Bend for the total flow of the Feather River at Shanghai Bend. The 200-year combined Shanghai Bend flows peaked at 300,000 cfs but had a mean bi-hourly flow of 271,000 cfs. These flows, which are within the design capacities of the Feather River channel, were routed to Nicolaus, combined with the Bear River flows, routed to the Fremont Weir and combined with the Sacramento River and Sutter Bypass flows. The flow at the SFRC peaks at 484,000 cfs with a one-day volume of 475,000 cfs. The peak exceeds the SFRC's capacity of 410,000 cfs. The 200-year flow hydrograph is shown on Chart 17.

H. **NO FAILURE CONDITIONS** - For the 200-year flood, a cursory estimate showed that the flow at the SFRC would increase by about 70,000 cfs if no levee failures occurred. This increase in flow would result in an increase in stage at Verona on the Sacramento River (location 34 on Chart 1) of approximately 0.7 feet. The stage difference lessens going downstream on the Sacramento River from Verona. In the Yolo Bypass, increases in stages range from 0.7 feet just downstream of Fremont Weir to 0.2 feet at Lisbon (location 49 on Chart 1). These stages are based on the assumption that both Sacramento Weir and Fremont Weir can handle the increase in flow.

For the 400-year flood, a cursory estimate showed that the flow at the SFRC would increase by about 190,000 cfs if no levee failures occurred. This increase in flow would result in an increase in stage at Verona on the Sacramento River (location 34 on Chart 1) of approximately 2.5 feet. The stage difference lessens going downstream on the Sacramento River from Verona. In the Yolo Bypass, increases in stages range from 0.7 feet just downstream of Fremont Weir to 0.7 feet at Lisbon (location 49 on Chart 1). These stages are based on the assumption that both Sacramento Weir and Fremont Weir can handle the increase in flow and that levees are infinetly high.

Table 15 on page 48 shows the 200- and 400-year differences.

The existing Sacramento River Flood Control System is very sensitive to any improvements made to it. Increasing upstream levee heights to provide higher levels of flood protection will impact on downstream

provide higher levels of flood protection will impact on downstream levees. It is important to look at overall effects when considering upstream levee improvements.

CHAPTER IV - HYDRAULIC ANALYSIS

1. **GENERAL** - As mentioned in Chapter I, the study area maintains a complex hydraulic balance during large flood events. Among these complexities are backwater effects, negative head differences, and weir flow all of which differ over time. Therefore it was necessary to use a program capable of handling these complex situations as they change in time. The DWOPER (Dynamic Wave Operational Model) program was chosen due to its capabilities and in-house experience.

   Although the American River is not actually part of the Sacramento Metro study area it was necessary to model it with DWOPER to determine its contribution to the flows in the Sacramento River, the Sacramento Weir and the Yolo Bypass.

2. **DWOPER OVERVIEW** - The basic input for DWOPER consists of input from GEDA (Geometric Elements for Cross Section Coordinates), inflow hydrographs at the upstream limit (boundary) of each river, lateral inflows at their corresponding locations in the system, and a stage hydrograph or rating curve at the downstream limit (boundary).

   The GEDA program is an interface between the channel geometric and roughness data, and DWOPER. It transforms the actual channel geometry and roughness data into a format compatible with DWOPER input formats. GEDA input consists of HEC-2 type cross sectional data, n-values for channel and overbank and a table of water-surface elevations which fall within the confines of the cross sections. GEDA computes the distances between cross sections along with the n-value and topwidth for each given water-surface elevation at each cross section.

   The output from GEDA is then used as input to DWOPER to describe the physical details of each river in the river system. Each river system may have one "main stem" river. Dynamic tributaries, those modeled with cross sections, may connect to the main stem river. However, a dynamic tributary may not connect to another dynamic tributary but a "lateral" inflow may enter the system at any point. Lateral inflows differ from dynamic tributaries in that they are simply input hydrographs. Flow out of a storm sewer is a good example of a lateral inflow. The Sacramento-American River junction is an example of a main stem-dynamic tributary junction, with the Sacramento being the main stem.

   Due to the DWOPER constraint of where dynamic tributaries can connect, it was necessary to break the study area into three separate DWOPER models. These will be called the Sacramento River, American River and Yolo Bypass models, respectively.

3. **MODEL CALIBRATION** - The flood events of 1986 and 1983 were chosen to calibrate the DWOPER model. The 1986 event was used to calibrate the model since it was the largest flood of record at many locations, a large amount

of field observations exist, and a large network of stream gaging stations were in place during the flood to measure the flows and elevations at many locations. It was reasoned that if the model can reproduce the flood of record, then it would do well estimating less frequent events such as the 100-, 200-, and 400-year events. To assure that the model was not biased towards the 1986 flood only, the 1983 event was used as a check. The next few paragraphs will detail the differences between the Sacramento River and American River models and how they were used to reproduce the 1986 flood.

A. SACRAMENTO RIVER MODEL - The Sacramento River model includes the Sacramento River from Tisdale Weir to Courtland, Sutter Bypass from Tisdale Weir to Fremont Weir, Feather River from the Bear River to the Sacramento River, Natomas Cross Canal from Pleasant Grove Canal to the Sacramento River and the American River from Nimbus to the Sacramento River (see Chart 1). The Sutter Bypass and the part of the Sacramento River below Fremont Weir are being used as the main stem river. Therefore, the Sacramento River above Fremont, Feather River, Natomas Cross Canal and American River are dynamic tributaries to the Sacramento River. Chart 19 shows a schematic of the main stem/dynamic tributary setup. This setup of the Sacramento River model is representative of the DWOPER model used for all flood events in this study.

(1) Boundary Conditions -

a. Main Stem River - The estimated flow hydrograph in the Sutter Bypass just downstream of Tisdale Weir was used as the upstream boundary hydrograph. This hydrograph was estimated by combining the recorded flows in the Butte Slough at Meridian (Chart 1, location 20) the Wadsworth Canal near Sutter (Chart 1, location 22) and the Tisdale Weir spill to the Sutter Bypass (Chart 1, location 12).

The recorded stage hydrograph at the Sacramento River at Snodgrass Slough stage recording station (Chart 1, location 48) was used as the lower boundary.

b. Dynamic Tributaries - The recorded flow hydrograph at the Sacramento River at Wilkins Slough gaging station (Chart 1, location 15) was used as the upper boundary inflow to the Sacramento River. The estimated flow hydrograph in the Feather River below the Bear River was used as the upper boundary inflow to the Feather River. This hydrograph was computed based on the estimated flow in the Feather River at Shanghai Bend (Chart 1, location 29), Honcut Creek estimated local flow and Bear River at Wheatland (Chart 1, location 30) flows. The upper boundary inflow to the Cross Canal was computed using HEC-1 and recorded rainfall values. The flow recorded at the American River at Fair Oaks gaging station (this location is not shown on Chart 1 but is basically the outflow from Lake Nimbus shown on Chart 5) was used

as the upper boundary flow for the American River. DWOPER uses the stage computed on the main river at the downstream end of the tributaries as the downstream boundary of the tributary. The upstream boundary hydrographs are shown on Chart 18.

(2) **N-Values** - The n-values ranged from .018 to .040 for channels and .04 to .08 for overbanks depending on location. N-values are the main vehicle for adjusting the stage and flow values in DWOPER. At times, n-values may seem slightly high or low but are usually used in a short reach to help simulate a different type of flow such as reverse flow.

(3) **Sacramento Weir** - The Sacramento Weir was modeled using a weir crest elevation of 21.5 feet msl., a weir length of 1830 feet and a weir coefficient of 2.5. The Sacramento Weir presented some modeling problems because of the flashboards. The flashboards eliminate modeling the weir as a fixed weir crest structure. Also, certain criteria exist as to when the flashboards should be removed. These criteria are based on the elevation at the Sacramento River at I-Street gage. Once the elevation at I-Street reaches 27.5 feet msl then the boards are to be removed. Therefore, it was necessary to estimate the elevation at the Sacramento Weir when the elevation at I-Street reaches 27.5 feet msl. This elevation was estimated to be approximately 28.2 feet msl. In the eyes of DWOPER, removal of the flashboards began when the average elevation at the weir (upstream downstream elevation/2) reached 28.5 msl. This removal took 6 hours and the final elevation after removal was 21.5 feet msl.

(4) **Fremont Weir** - The crest of the Fremont Weir is 30.5 feet msl. Over the years, much sediment has been deposited in front of the weir. In 1986 it was estimated that the ground on the upstream side of the weir averaged approximately 1.5 feet above the weir crest. Therefore, the effective elevation of the Fremont Weir was estimated to be 32.0 feet msl. A weir length of 7000 feet and a weir coefficient of 2.5 were used. Although the actual weir is longer than 7000 feet, its perpendicular length to the Sacramento River is close to 7000 feet. The original design rating curve for the Fremont Weir is shown on Chart 49. This curve may not be representative of existing conditions. Since the 1986 flood, sediment has been removed from the Fremont Weir area. No flow has occurred over the Weir since 1986 so it has not been possible to get any flow measurements since the 1986 flood event.

(5) **Nelson Bend Training Structure** - The Nelson Bend training structure is located across the Feather floodplain where it intersects the Sutter Bypass. This structure keeps low flows in the main Feather River channel as it turns southward. The elevation of this structure is 36.5 feet msl. In the DWOPER model, once the Feather River waters exceed this elevation, water spills into the Sutter

Bypass. The amount of water entering the Sutter Bypass depends on the elevation of the Feather River water and the elevation of the Sutter Bypass water. DWOPER accounts for weir submergence.

(6) **Lateral Inflows** - The existing pumping plants on the Natomas Cross Canal were treated as lateral inflows. The contribution of the NEMDC to the American River was treated as a lateral inflow in this model. The NEMDC is treated with more detail in the American River model.

(7) **Results** - The DWOPER reconstitutions of the 1986 and 1983 events are shown on Charts 20 and 21, respectively. Due to the quality of these reconstitutions, it was assumed that DWOPER would do an acceptable job of computing elevations associated with large flood events in the area covered by the Sacramento River model.

B. **AMERICAN RIVER MODEL** - The American River model includes the American River from Nimbus to the Sacramento River and the Natomas East Main Drain (NEMDC) from Sankey Road (see Chart 1 for location) to the American River. The American River is the main stem river and the NEMDC is a dynamic tributary. Chart 19 shows a schematic diagram of this model.

(1) **Boundary Conditions** - The Fair Oaks gage was used as the upper boundary inflow hydrograph to the American River. The lower boundary for the American River was computed by the Sacramento River model. The upper boundary inflow hydrograph to the NEMDC was computed using HEC-1. The American River hydrograph is shown on Chart 18.

(2) **N-Values** - N-values fell within the range used in the Sacramento River model.

(3) **Lateral Inflows** - Lateral inflows consist of Arcade Creek, Dry Creek, small tributaries in the Elverta drainage area and pumping plants. The Arcade, Dry and Elverta inflows were computed by HEC-1 using the data described in Chapter III. The pumping plant capacities were provided by the City of Sacramento. All pumps were assumed to pump at full capacity throughout the duration of the flood. Total pumping capacity is approximately 1440 cfs.

(4) **Overflow From Natomas Cross Canal** - Based on field observation, it was estimated that when the peak stages were occurring in the Natomas Cross Canal, a peak flow of approximately 500 cfs flowed south from the Natomas Cross Canal drainage, over Sankey Road, and into the NEMDC drainage. The overflow raises the water-surface in the NEMDC. The amount of overflow is only an estimate. No flow measurements were made during the 1986 flood.

(5) **Results** - The DWOPER calibration to the high water marks recorded in the NEMDC during the 1986 event are shown on Chart 20. No high water marks were available for the 1983 event in the NEMDC.

C. **YOLO BYPASS MODEL** - The Yolo Bypass model includes the Yolo Bypass from Fremont Weir to the Lisbon gaging station and the Sacramento Bypass from the Sacramento Weir to the Yolo Bypass. The Yolo Bypass is the main stem and the Sacramento Bypass is a dynamic tributary. Chart 22 shows a schematic diagram of this model.

(1) **Boundary Conditions** - The upper boundary inflow hydrographs to the Yolo Bypass and the Sacramento Bypass were computed with the Sacramento River model. These inflow hydrographs are the spills over the Fremont and Sacramento weirs, respectively.

The observed stage hydrograph at Lisbon was used as the downstream boundary condition. These inflow hydrographs are the computed hydrographs shown on Charts 20 and 21. The Lisbon stage hydrograph is shown on Chart 23.

(2) **N-Values** - N-values fell within the range used in the Sacramento River Model.

(3) **Lateral Inflows** - Lateral inflows consist of Cache Creek and Putah Creek. Other small streams contribute but were not considered.

(4) **Results** - The DWOPER calibrations to observed stage hydrographs and high water marks for the 1986 flood are shown on Chart 20. The only available data for the 1983 flood are shown on Chart 21.

4. **SYNTHETIC FLOODS** -

A. **GENERAL** - Water-surface elevations for the 100-, 200- and 400-year floods were computed for many locations in the basin using the Sacramento River, American River, and Yolo Bypass models.

B. **CONCURRENCIES** - Several historical events were reviewed to determine the concurrence of peak flows at the confluence of the Sacramento and American Rivers. The United States Geological Survey (USGS) Water Resources Data publications were used to obtain the maximum daily flows for the Sacramrnto River near Verona, American River at H Street, and Sacramento River at I Street gaging stations. The I Street gage was moved downstream to Freeport in October 1979. Table 8 shows the dates the maximum daily flows occured for each of the floods.

TABLE 8

HISTORICAL FLOOD PEAK CONCURRENCIES

WATER YEAR	VERONA	H STREET	I STREET	FREEPORT
1955	12/23/55	12/24/55	12/23/55	
1956	1/17/56	1/17/56	1/17/56	
1964	12/25/64	12/24/64	12/14/64	
1983	1/30/83	1/28/83		1/29/83
	3/15/83	3/14/83		3/14/83
1986	2/20/86	2/19/86		2/19/86

The flood hydrographs are broad peaked. The difference between the peak flow on the day shown and the peak flow on the previous or next day is generally less than 5 percent.

(1) **100-Year** - The 100-year event was assumed to be concurrent over the entire study area. This assumption is based on the fact that many locations experienced a 70-year event and that it is not unreasonable to assume that a 100-year event could occur over the area. The timing of the 100-year hydrographs is based on the timing of the flows that occurred during the 1986 event.

(2) **200-Year** - For the 200-year event, it was decided that having a 200-year event everywhere would result in an event actually greater than a 200-year event. Therefore, when a 200-year event was assumed to occur on one river a 100-year event was assumed concurrent over the rest of the area.

a. **Sacramento River** - The 200-year on the Sacramento River is assumed to be concurrent with a 100-year on the American River and a 100-year on all local streams. The timing of the peaks for the 200-year event is based on the timing of the 1986 event.

b. **American River** - The 200-year on the American River is assumed to be concurrent with a 100-year on the Sacramento River and a 100-year on all local streams. The timing of the 200-year event is based on the 1986 flood.

c. **Yolo Bypass** - The Yolo Bypass is a flood control bypass which accepts flow from the Sacramento and American Rivers. Therefore, concurrencies of the Sacramento and American Rivers affect the elevations in the Yolo Bypass.

(3) **400-Year** - For the 400-year event, it was decided that having a 400-year event everywhere would result in an event actually greater

than a 400-year event. Therefore, when a 400-year event was assumed to occur on one river a 100-year event was assumed concurrent over the rest of the area.

a. Sacramento River - The 400-year on the Sacramento River is assumed to be concurrent with a 100-year on the American River and a 100-year on all local streams. The timing of the peaks for the 400-year event is based on the timing of the 1986 event.

b. American River - The 400-year on the American River is assumed to be concurrent with a 100-year on the Sacramento River and a 100-year on all local streams. The timing of the 400-year event is based on the 1986 flood.

c. Yolo Bypass - The Yolo Bypass is a flood control bypass which accepts flow from the Sacramento and American Rivers. Therefore, concurrencies of the Sacramento and American Rivers affect the elevations in the Yolo Bypass.

(4) Sensitivity Analysis - As indicated above, it has been assumed that the American River will not exceed the 100-year flow when the Sacramento River is experiencing a flow of 100-year or greater. The belief is that a 200-year on the Sacramento River combined with a 200-year on the American River would result in an event greater that a 200-year. The same belief holds for the 400-year event. To perform a coincident frequency analysis on the American and Sacramento Rivers would be extremely rigorous and difficult, especially given the complexity of the basin due to reservoir regulation. In light of this, it was decided to perform the "what if" analysis and compute the flows and stages for a condition where the American River would be experiencing the same magnitude flood as the Sacramento River. No frequency has been assigned to the stages resulting from this coincident frequency analysis. The results are shown on Table 16, page 49. When loooking at this table, keep in mind that the flows and stages in the Sacramento River below the American River for the filenames D200SAM and D400SAM should be considered hypothetical. These flows and stages would never be reached since levees would be overtopped. These flows and stages equate to infinitely high levees on the Sacramento River. It is also assumed that the Sacramento Weir can handle the flows shown.

C. SACRAMENTO RIVER MODEL -

(1) Boundary Conditions - The 100, 200- and 400-year hydrographs for the Sacramento River at Wilkins Slough, Sutter Bypass below Tisdale Weir, and Feather River below the Bear River were computed as part of the volume-frequency analysis described in Chapter III. The inflow to the Cross Canal was computed using HEC-1. The 100-, 200,

and 400-year flows on the American River were computed as detailed in reference F. The flow-frequency curve for the American River, which shows the 100-, 200-, and 400-year peaks, is shown on Chart 6. The inflow hydrographs are shown on Charts 24, 25 and 26.

A rating curve of flow vs. stage was used for all events at the downstream boundary at the Sacramento River at Snodgrass Slough recording station. Due to tidal effects, which can result in different flows for the same stage, no actual rating curve exists at this location. A rating curve was developed by using the actual 1986 recorded stages at Snodgrass Slough and the corresponding flows computed with DWOPER. The flow-stage points were plotted and a smooth curve was drawn through the points. The rating curve is shown on Chart 27.

(2) **N-Values** - N-values obtained in the calibration of the 1986 flood were used for the synthetic events.

(3) **Sacramento Weir** - The Sacramento Weir was modeled the same as in the reconstitution of the 1986 flood.

(4) **Fremont Weir** - As detailed above, for the 1986 flood, the Fremont Weir was at an effective elevation of 32.0 feet msl. Subsequent to the 1986 event, the State of California has removed approximately two-thirds of the sediment upstream of the weir and exposed the actual weir crest. Therefore, the effective elevation of the Fremont Weir for the synthetic events has been assumed to be 31.0 feet msl. This one foot change is two-thirds the difference between the 32.0 used for the 1986 and the actual sill elevation of 30.5 msl.

(5) **Nelson Bend** - The Nelson Bend structure was modeled the same as in the reconstitution of the 1986 flood.

(6) **Lateral Inflows** - Lateral inflows were treated the same as they were in the reconstitution of the 1986 flood.

D. AMERICAN RIVER MODEL -

(1) **Boundary Conditions** - The 100-, 200- and 400-year hydrographs were computed as detailed in reference F. These hydrographs were used as the upstream boundary for the American River. The upstream boundary for the NEMDC was computed using HEC-1 and the criteria listed in Chapter III.

The downstream boundary for the American River was computed by the Sacramento River model.

(2) **N-Values** - The N-values verified for the 1986 flood were used for the synthetic events.

(3) **Lateral Inflows** - Lateral inflows consisted of Arcade Creek, Dry Creek, small tributaries in the Elverta drainage and pumping plants. The Arcade, Dry and Elverta inflows were computed by HEC-1 and the data described in Chapter III. All pumps were assumed to pump at full capacity throughout the duration of all events. Total pumping capacity is approximately 1440 cfs.

(4) **Overflow From Natomas Cross Canal** - Based on estimates of flow splits in the Cross Canal drainage area for the 100-year flood, it was estimated that when the peak stages were occurring in the Natomas Cross Canal, a peak flow of approximately 760 cfs flowed from the Natomas Cross Canal drainage, over Sankey Road, and into the NEMDC drainage. This flow is only an estimate and should be treated that way. The 760 cfs value was used for all events.

E. YOLO BYPASS MODEL -

(1) **Boundary Conditions** - The upper boundary 100-, 200-, and 400-year inflow hydrographs to the Yolo Bypass and the Sacramento Bypass were computed with the Sacramento River model. These inflow hydrographs vary greatly depending on assumed conditions in the basin (ie, increased upstream storage on the American River or levee improvements). They are too numerous to show in this report. However, Tables 17 to 23, pages 50-56, list the flows over Fremont and Sacramento weirs for a variety of conditions.

A rating curve of flow vs. stage was used for all events as the downstream boundary at the Lisbon location. No actual rating curve exists at this location. A rating curve was developed by using the actual 1986 recorded stages at Lisbon gage and the corresponding flows computed with DWOPER. The flow-stage points were plotted and a smooth curve was drawn through the points. The rating curve is shown on Chart 28.

(2) **N-Values** - N-values verified for the 1986 flood were used for the synthetic events.

(3) **Lateral Inflows** - Lateral inflows consist of Cache Creek and Putah Creek. Due to time and money constraints, and since their flows contributions are a small percentage of the total Yolo Bypass flow, the 100-year contributions from Cache and Putah Creeks were not computed. However, in order to have some local contribution from these streams in the DWOPER model, the 1986 flows were used as the concurrent inflows. Other small streams contribute but they were not considered.

F. **SYNTHETIC FLOOD RESULTS** - Stage-frequency curves and water-surface profiles for the study area are discussed in Chapter V.

G. **LEVEE FAILURE ASSUMPTIONS** - When extreme floods occur, levees have failed for unknown reasons, because of overtopping at low points or at known weak areas. A review of how each planning study defined levee failures revealed a number of different ideas. Table 9 details the assumptions used in breaching levees in the system for this hydraulics study. Levees are to be failed sequentially as the criteria are exceeded. Each location was failed in 1 hour with the maximum breach width being 200 feet. The breach width is based on evidence obtained from the 1986 levee failures on the Yuba River and the Mokelumne River. The bottom of the breach was held to the existing ground level on the land side of the levee. Flow through the breaks is computed using the weir formula of

$$FLOW=CLH^{1.5}$$

where C=the weir coefficient, L=breach width and H=the head difference between the River elevation and the bottom of the breach. DWOPER will check to see if submergence is a factor but only in certain situations will it keep track of the tailwater elevation. In cases where the tailwater has an effect but DWOPER cannot compute it, the weir coefficient was lowered to account for submergence that is not computed by DWOPER.

TABLE 9

LEVEE FAILURE ASSUMPTIONS

LEVEE REACH	FREEBOARD (feet)
1. **RECLAMATION DISTRICT 1000**	
a. Sacramento River (Left Bank) - Natomas Cross Canal to Natomas Main Drain	3
b. Natomas Cross Canal (North and South Levees)	3
c. Natomas East Main Drain and South Levee to the Natomas Main Drain	3
2. **AMERICAN RIVER LEVEE SYSTEM**	
a. Right Bank, Sacramento River to River Mile 5.2	3
b. Right Bank, Upstream of River Mile 5.2	4
c. Left Bank, Sacramento River to River Mile 5.2	5
d. Left Bank, River Mile 5.2 to River Mile 7.8	5
e. Left Bank, Upstream of River Mile 7.8	4
3. **DRY CREEK, ARCADE CREEK, AND THE EAST LEVEE OF THE NATOMAS EAST MAIN DRAIN**	3
4. **SACRAMENTO RIVER (LEFT BANK) FROM THE AMERICAN RIVER TO FREEPORT**	3
5. **SACRAMENTO RIVER (RIGHT BANK) FROM THE SACRAMENTO BYPASS TO RIVERVIEW**	3
6. **YOLO BYPASS AND TRIBUTARY LEVEES**	3
7. **SACRAMENTO RIVER (RIGHT BANK) FROM THE NATOMAS CROSS CANAL TO THE SACRAMENTO BYPASS**	3

As discussed below, concessions were necessary to model some failures.

1. **NATOMAS EAST MAIN DRAIN** - Due to constraints in the DWOPER program, it was necessary to simulate west levee failures of the Natomas East Main Drain (NEMDC) by failing the north bank of the American River just downstream of where the NEMDC starts to parallel the American River.

2. **SACRAMENTO RIVER (RIGHT BANK)** - Failures of the right (west) levee of the Sacramento River from the Natomas Cross Canal to the Sacramento Bypass will flood the area designated as Area C. This area, shown on Chart 1, is bounded by the Sacramento River on the north and east, the Sacramento Bypass on the south and the Yolo Bypass on the west. This area encompasses Reclamation Districts 1600, 827, 785, and part of 537. Water flowing into Area C will pond up to elevation 30.2.

At this elevation, it will break back into the Yolo Bypass where the north levee of the Sacramento Bypass joins the east levee of the Yolo Bypass. This return flow is discussed in Section 5, Area C Return Flow, below.

3. **YOLO BYPASS** - Failures of the left (east) levee of the Yolo Bypass will flood Area C and West Sacramento. This water will return to the Yolo Bypass. See Section 5, Area C Return Flow, below.

4. **AMERICAN RIVER** - Water flowing through failures in the right (north) levee of the American River will pond in the North Sacramento area behind the right bank levee up to elevation 36.0 feet. At elevation 36, the right bank levee will be overtopped and fail just upstream of the NEMDC. The water in the pond area will flow through the break and enter the American River. It was not possible to model this entire failure scenario using only DWOPER. To model the right bank failures, three steps were taken.

   First, the American River DWOPER model was run and the flows through the right bank failures were computed.

   Second, the flows through the right bank failures were combined and ponded in the right bank until the pond reached elevation 36.0. The right bank pond elevation was computed by converting the inflow to storage and comparing the storage to the storage-elevation curve computed for the pond area. The storage-elevation curve was calculated from USGS 7.5 minute quadrangles. Once the elevation reached 36.0 the right bank levee was failed and the flow hydrograph through the break was computed by taking into account the head difference between the pond area and the American River.

   Lastly, to include the effects of this return hydrograph, the American River DWOPER model was run again and the return flow hydrograph was included as a lateral flow.

5. **AREA C RETURN FLOW** - It was not possible to model the entire failure scenario for Area C using only DWOPER. To model Area C the following steps were taken.

   First, using the Sacramento River and Yolo Bypass DWOPER models and the 100-year event, the sequence of failure between the Sacramento River and Yolo Bypass was estimated. It was determined that the Sacramento River side of Area C will fail slightly before the Yolo Bypass side. Using these models, the flow hydrographs through the breaks were computed.

   Second, based on timing of the failures, assumptions were made as to which sections of Area C would be filled by water flowing through the breaks. Storage-elevation curves for the areas above and below I-5

were computed using USGS 7.5 minute quadrangles. The water-surface elevation in Area C was computed by converting the inflow to storage and comparing the storage to the storage-elevation curves. From the storage curves, it was determined that by the time the water surface elevation in Area C reaches 30.2, inflow from the Sacramento River would fill the area above I-5 while inflow from the Yolo Bypass will fill the area below I-5. Once the water-surface reached 30.2, the east levee of the Yolo Bypass was failed and the return flow hydrograph to Yolo Bypass was computed by taking into account the water-surface elevations in Area C and the Yolo Bypass. Once this return flow began, no more flow enters Area C from the Yolo Bypass. However, due to head differences, water continues to enter Area C through the Sacramento River break.

Lastly, to include the effects of this return hydrograph, the Yolo Bypass DWOPER model was run again and the return flow hydrograph was included as a lateral flow.

CHAPTER V - STAGE-FREQUENCY CURVES AND WATER-SURFACE PROFILES

1. **GENERAL** - Stage-frequency curves and water-surface profiles were developed for a variety of levee failure assumptions and physical conditions throughout the study area. These curves and profiles were necessary to determine current levels of flood protection throughout the Sacramento Area and to determine the frequency of the 1986 event at various locations. They were also necessary to determine the benefits of the various project alternatives.

   Stage frequency curves were developed for:
   (A) Sacramento River at West End Fremont Weir (location 38 on Chart 1)
   (B) Sacramento River at Verona (location 34 on Chart 1)
   (C) Sacramento River at I-Street (location 45 on Chart 1)
   (D) Yolo Bypass at Woodland (location 40 on Chart 1)
   (E) Yolo Bypass at Lisbon (location 49 on Chart 1)

   The development of the stage-frequency curves is discussed in section 3 of this chapter. These curves are shown on Charts 29 through 33.

   Water-surface profiles were developed for the:
   (A) Sacramento River
   (B) Yolo Bypass and
   (C) Sacramento Bypass

   Water-surface profiles are shown on Charts 34 thru 46. These profiles represent different physical conditions. They are discussed in section 4 of this chapter. Comparisons of computed, 1986, and design water-surface profiles, shown an Charts 44 thru 46, and discussed in section 5 of this chapter.

2. **LEVEE FAILURE ASSUMPTIONS AND PHYSICAL CONDITIONS** - After looking at several different flow, levee failure and physical conditions, several areas popped up as the most likely to fail based on the freeboard criteria detailed in Chapter IV. Table 10 lists these locations.

TABLE 10
LEVEE FAILURE LOCATIONS

#	LOCATION
1	Right (West) levee Sacramento River from Mile 78.5 to mile 72.5 (across river from Verona). Failures here flood Area C.
2	Right (West) levee Sacramento River from Mile 51 to 46 (South of West Sacramento)
3	Left (South) levee American River in the vicinity of Mayhew Drain
4	Right (North) levee American River many locations from Arden Treatment Plant to H-Street
5	Right (North) levee American River downstream of Natomas East Main Drain
6	Right (West) levee Natomas East Main Drain upstream and downstream of El Camino
7	Left (East) levee of the Yolo Bypass upstream of the Sacramento Bypass. Failures here flood Area C.
8	Left (East) levee of the Yolo Bypass between the Sacramento Bypass and I-80 and approximately 1 mile downstream of I-80. These failures will flood West Sacramento.

As stated earlier, all breaks are sequential. When water flows through a break it is lost to the system, unless special consideration is taken to return the flow as with the American River and Area C.

3. **STAGE-FREQUENCY CURVES AND WATER SURFACE PROFILES** - During the course of this study it was necessary to determine the sensitivity of different types of projects. The projects ranged from levee improvements without an increase in available upstream storage on the American River to no levee improvements with an increase in upstream storage on the American River. The exact types of levee improvements were not considered. The approach taken was: If this location is fixed and that one isn't, what will the effects be. Several combinations were considered. The results of these combinations are displayed on the stage-frequency curves, Charts 29-33, and water-surface profiles, Charts 34 to 43 and on Tables 17 to 23, pages 50-56. Also, results have been tabulated for combinations other than those

displayed on the curves and profiles. These results are also shown on Tables 17-23.

A. SACRAMENTO RIVER AT THE WEST END OF FREMONT WEIR - The curves for this location are shown on Chart 29. The numbers in parenthesis in each curve description denote the levee failure locations on Table 10, page 37. The 200- and 400- year elevations are the result of the 200- and 400-year events in the Sacramento River basin and a 100-year event elsewhere, as discussed in Chapter IV. The shape of the curves above the 200-year event is the result of levee failures upstream on the Feather River. These levee failures reduce the peak flow since the water spreads over the floodplain.

1. **CURVE NUMBER 1** - Curve number 1 represents existing conditions freeboard levee failures on the American River (3,4) and on the NEMDC (6). For this curve, the effective weir crest of the Fremont Weir was 32.0 feet. This sediment elevation reflects the estimated effective weir crest during the 1986 flood and results in higher Sacramento River elevations downstream of Fremont Weir and upstream of Sacramento Weir. The 200 and 400-year events also reflect levee failure on the American River at location 5.

2. **CURVE NUMBER 2** - Curve number 2 represents existing conditions freeboard levee failures on the Sacramento River (1) on the American River (3,4) and on the NEMDC (6). For this curve, the effective weir crest of the Fremont weir was 31.0 feet. The 200- and 400-year events also reflect levee failure on the American River at location 5.

3. **CURVE NUMBER 3** - Curve number 3 represents project conditions with levee failures on the Sacramento River (1). Project conditions include levee improvements at all locations except location 1 and an increase in upstream storage so that the objective release from Folsom will be 115,000 cfs for all events. For this curve the effective weir crest of Fremont weir was 31.0 feet.

4. **CURVE NUMBER 4** - Curve number 4 is a preproject condition curve which represents freeboard failures on the south levee of the Natomas Cross Canal, on the American River (4,5) and on the NEMDC (7). The weir crest of Fremont Weir is at 30.5 (all sediment has been removed). The south levee of the Natomas Cross Canal does not fail at the 100-year level, only at the 200- and 400-year events. Table 23, page 56, lists the elevations at various locations in the area for these conditions.

B. SACRAMENTO RIVER AT VERONA - The curves for this location are shown on Chart 30. The numbers in parenthesis in each curve description denote the levee failure locations on Table 10, page 37. The 200- and 400- year elevations are the result of the 200- and 400-year events in the Sacramento River basin and a 100-year event elsewhere, as discussed in Chapter IV. The shape of the curves above the 200-year event is the

result of levee failures upstream on the Feather River. These levee failures reduce the peak flow since the water spreads over the floodplain.

1. **CURVE NUMBER 1** - Curve number 1 represents existing conditions freeboard levee failures on the American River (3,4) and on the NEMDC (6). For this curve, the effective weir crest of the Fremont Weir was 32.0 feet. This sediment elevation reflects the estimated effective weir crest during the 1986 flood and results in higher Sacramento River elevations downstream of Fremont Weir and upstream of Sacramento Weir. The 200 and 400-year events also reflect levee failure on the American River at location 5.

2. **CURVE NUMBER 2** - Curve number 2 represents existing conditions freeboard levee failures on the Sacramento River (1) on the American River (3,4) and on the NEMDC (6). For this curve, the effective weir crest of the Fremont weir was 31.0 feet. The 200- and 400-year events also reflect levee failure on the American River at location 5.

3. **CURVE NUMBER 3** - Curve number 3 represents project conditions with levee failures on the Sacramento River (1). Project conditions include levee improvements at all locations except location 1 and an increase in upstream storage so that the objective release from Folsom will be 115,000 cfs for all events. For this curve the effective weir crest of Fremont weir was 31.0 feet.

4. **CURVE NUMBER 4** - Curve number 4 is a preproject condition curve which represents freeboard failures on the south levee of the Natomas Cross Canal, on the American River (4,5) and on the NEMDC (7). The weir crest of Fremont Weir is at 30.5 (all sediment has been removed). The south levee of the Natomas Cross Canal does not fail at the 100-year level, only at the 200- and 400-year events. Table 23, page 56 lists the elevations at various locations in the area for these conditions.

C. **SACRAMENTO RIVER AT I-STREET** - The curves for this location are shown on Chart 31. The shape of curves 1, 2 and 3 reflect the shape of the peak flow frequency curve for the American River at Fair Oaks. Under existing conditions, Folsom will loose control at the 63-year level. This loss of control affects the I-Street location, as the above mentioned curves rise sharply at the 63-year level. Curves 1, 2 and 3 follow the general shape of the American River curve shown on Chart 7. The numbers in parenthesis in each curve description denote the levee failure locations on Table 10, page 37.

Curves 1 and 2 do not reflect any levee failures on the Sacramento River downstream of the American River. Events on the American River which cause these high elevations will result in freeboard criteria being

exceeded, and in some cases, levees overtopped. For these curves the levees on the Sacramento River downstream of the American River are considered infinitely high.

1. **CURVE NUMBER 1** - Curve number 1 represents existing conditions freeboard levee failures on the American River (3,4) and on the NEMDC (6). For this curve, the effective weir crest of the Fremont Weir was 32.0 feet. This sediment elevation reflects the estimated effective weir crest during the 1986 flood and results in higher Sacramento River elevations downstream of Fremont Weir and upstream of Sacramento Weir. The 200 and 400-year events also reflect levee failure on the American River at location 5.

2. **CURVE NUMBER 2** - Curve number 2 represents existing conditions freeboard levee failures on the Sacramento River (1) on the American River (3,4) and on the NEMDC (6). For this curve, the effective weir crest of the Fremont weir was 31.0 feet. The 200- and 400-year events also reflect levee failure on the American River at location 5.

3. **CURVE NUMBER 3** - Curve number 3 represents existing conditions with levee failures on the Sacramento River (1,2) on the American River (3,4) and on the NEMDC (6). For this curve, the effective weir crest of the Fremont weir was 31.0 feet. The 200- and 400-year events also reflect levee failure on the American River at location 5.

4. **CURVE NUMBER 4** - Curve number 4 represents project conditions with levee failures on the Sacramento River (1). Project conditions include levee improvements at various locations and an increase in upstream storage so that the objective release from Folsom will be 115,000 for all events. For this curve the effective weir crest of Fremont weir was 31.0 feet.

D. **<u>YOLO BYPASS AT WOODLAND</u>** - The curves for this location are shown on Chart 32. The numbers in parenthesis in each curve description denote the levee failure locations on Table 10, page 37.

1. **CURVE NUMBER 1** - Curve number 1 represents existing conditions freeboard levee failures on the American River (3,4) and on the NEMDC (6). For this curve, the effective weir crest of the Fremont Weir was 32.0 feet. This sediment elevation reflects the estimated effective weir crest during the 1986 flood and results in higher Sacramento River elevations downstream of Fremont Weir and upstream of Sacramento Weir. The 200 and 400-year events also reflect levee failure on the American River at location 5.

2. **CURVE NUMBER 2** - Curve number 2 represents existing conditions freeboard levee failures on the Sacramento River (1,2) on the American River (3,4) on the NEMDC (6) and on the Yolo Bypass (7). It also includes return flow from Area C. For this curve, the effective

weir crest of the Fremont Weir was 31.0 feet. The 200 and 400-year events also reflect levee failure on the American River at location 5.

3. **CURVE NUMBER 3** - Curve number 3 represents existing conditions with levee failures on the Sacramento River (1,2) on the American River (3,4) on the NEMDC (6) and on the Yolo Bypass (7,8). For this curve, the effective weir crest of the Fremont weir was 31.0 feet. The 200and 400-year events also reflect levee failure on the American River at location 5.

4. **CURVE NUMBER 4** - Curve number 4 represents project conditions with levee failures on the Sacramento River (1) and the the Yolo Bypass (7,8). It also includes return flow from Area C. Project conditions include levee improvements at various locations and an increase in upstream storage so that the objective release from Folsom will be 115,000 for all events. For this curve the effective weir crest of Fremont weir was 31.0 feet.

5. **CURVE NUMBER 5** - Curve number 5 is a preproject condition curve which represents freeboard failures on the south levee of the Natomas Cross Canal, on the American River (4,5) and on the NEMDC (7). The weir crest of Fremont Weir is at 30.5 (all sediment has been removed). The south levee of the Natomas Cross Canal does not fail at the 100-year level, only at the 200- and 400-year events. Table 23, page 56, lists the elevations at various locations in the area for these conditions.

E. **YOLO BYPASS AT LISBON** - The curves for this location are shown on Chart 33. The numbers in parenthesis in each curve description denote the levee failure locations on Table 10, page 37.

1. **CURVE NUMBER 1** - Curve number 1 represents existing conditions freeboard levee failures on the American River (3,4) and on the NEMDC (6). For this curve, the effective weir crest of the Fremont Weir was 32.0 feet. This sediment elevation reflects the estimated effective weir crest during the 1986 flood and results in higher Sacramento River elevations downstream of Fremont Weir and upstream of Sacramento Weir. The 200 and 400-year events also reflect levee failure on the American River at location 5.

2. **CURVE NUMBER 2** - Curve number 2 represents existing conditions freeboard levee failures on the Sacramento River (1,2) on the American River (3,4) on the NEMDC (6) and on the Yolo Bypass (7). It also includes return flow from Area C. For this curve, the effective weir crest of the Fremont Weir was 31.0 feet. The 200 and 400-year events also reflect levee failure on the American River at location 5.

3. **CURVE NUMBER 3** - Curve number 3 represents existing conditions with levee failures on the Sacramento River (1,2) on the American River (3,4) on the NEMDC (6) and on the Yolo Bypass (7,8). For this curve, the effective weir crest of the Fremont weir was 31.0 feet. The 200and 400-year events also reflect levee failure on the American River at location 5.

4. **CURVE NUMBER 4** - Curve number 4 represents project conditions with levee failures on the Sacramento River (1) and the the Yolo Bypass (7,8). It also includes return flow from Area C. Project conditions include levee improvements at various locations and an increase in upstream storage so that the objective release from Folsom will be 115,000 for all events. For this curve the effective weir crest of Fremont weir was 31.0 feet.

5. **CURVE NUMBER 5** - Curve number 5 is a preproject condition curve which represents freeboard failures on the south levee of the Natomas Cross Canal, on the American River (4,5) and on the NEMDC (7). The weir crest of Fremont Weir is at 30.5 (all sediment has been removed). The south levee of the Natomas Cross Canal does not fail at the 100-year level, only at the 200- and 400-year events. Table 23, page 56, lists the elevations at various locations in the area for these conditions.

4. **COMPUTED WATER-SURFACE PROFILES** - Charts 34 to 43 show water-surface profiles for various conditions. These profiles represent the frequency curves described above and the sensitivity analysis numbers presented on Tables 17-22, pages 50-55. The profiles represent preproject and project conditions.

For the Sacramento River, Yolo Bypass and Sacramento Bypass the legend for each profile lists the filename on Tables 17 to 22 (each filename represents a specific DWOPER computer run) which the respective profile represents. By looking up the filename for the profile on Tables 17 to 22, it is possible to see where levee failures have been assumed to occur for that profile. Table 11 below lists a cross-reference between the profiles and which table to find the levee failure assumptions.

TABLE 11
PROFILE AND LEVEE FAILURE CROSS-REFERENCE

PROFILE	TABLE
DWE310B	20
DWE320B	20
DWE340B	20
DWY310C	20
DWY320BC	20
DWY340C	20
DWA310B	20
DWA320B	20
DWA340B	20
DME310B	17
DME320B	18
DME340B	19
DYY310B	17
DYY320B	18
DYY340B	19
DYA310B	17
DYA320B	18
DYA340B	19

These profiles show the effects of levee failures based on the freeboard criteria from Table 9, page 33. They reflect 100-, 200-, and 400-year flows on the Sacramento River and a 100-year flow (234,000 cfs) on the American River. When a 200- or 400-year event is occurring on the American River concurrently with the 100-year on the Sacramento River, flows and stages will be higher in the Sacramento River and Yolo Bypass below the Sacramento Bypass. The difference for the 200-year can be seen on Table 18, while the difference at the 400-year level can be seen on Table 19.

5. **DESIGN WATER SURFACE PROFILES** - Design water-surface profiles for the Sacramento River, Yolo Bypass and Sacramento Bypass are shown on Charts 44 to 46. These Charts show the design, 1986 computed and 100-year computed water-surface profiles. The design elevations are those which were used to originally design the Sacramento River Flood Control System. The 1986 profiles were computed by the DWOPER model. The 100-year profiles are taken from run DME310B1 on Tables 17 to 22, pages 50-55.

6. **SENSITIVITY ANALYSIS** - Elevations listed on Tables 17 to 23, pages 50-56, represent different physical conditions in the basin. On the far right of

these tables are several columns under the Failure Location heading. Where an X appears, a levee failure has been assumed. By comparing runs with and without failures at certain locations, it is easy to see what effects are caused by failures and/or levee fixes.

CHAPTER VI - SACRAMENTO WEIR MODIFICATIONS

1. **GENERAL** - The State of California has expressed interest in removing the gates at the Sacramento Weir. Operation of these gates is expensive and a labor intensive effort. As part of the Sacramento Metro study, the effects of removing the gates and keeping the weir at the current elevation or removing the gates and lowering the weir were looked at.

2. **GATE REMOVAL ONLY** - The main concern about gate removal is that it would result in more frequent flooding and higher flood elevations in the Yolo Bypass. Chart 47 shows a plot of the 1986 observed data for the Sacramento River at the West End Fremont Weir and the Sacramento River at the North End of the Sacramento Weir, along with the actual weir crests. This plot shows that, without gates, flow over the Sacramento Weir would have started approximately 36 hours before it actually did and approximately 6 hours prior to flow starting over Fremont Weir.

   Comparisons were also made using the 100-year flood. The results of these comparisons were consistent with the 1986 flood. Table 22 shows a comparison of elevations with and without gates. This comparison shows that removal of the gates has virtually no effect in the Yolo Bypass when looking at the peak stages. Chart 48 is a water-surface profile plot of the Sacramento River which shows the effects of gate removal.

3. **GATE REMOVAL AND LOWERING** - A sensitivity analysis was made to estimate the effects in the Yolo Bypass of removing the gates and lowering the weir crest. This analysis is presented on Table 22 and shows virtually no effect in the Yolo Bypass. However, water would flow into the Yolo Bypass more often under this alternative.

CHAPTER VII - YOLO BYPASS WIND-WAVE ANALYSIS

1. 1986 WIND-WAVE RUNUP ESTIMATES -

A. GENERAL - Estimates of wave runup and wind set for the February 1986 flood were made for two locations in the Yolo Bypass. The first location is on the east levee of the Yolo Bypass about 3,400 feet south of the I-80 causeway. The second is on the west levee of the Yolo Bypass about 5,400 feet south of the I-80 causeway. These locations were chosen based on wind patterns of the general area and fetch distances in the bypass.

B. RUNUP CALCULATIONS - Wind data were taken from recors at the Sacramento Executive Airport which is about 4 miles east of the Yolo Bypass. Three days were selected for analysis. Table 12 shows tha fastest wind speed of 1-minute duration for these days.

TABLE 12

1986 WIND-WAVE ANALYSIS

LOCATION	DATE	FETCH LENGTH (mi)	ACTUAL WIND SPEED (mph)	ADJUSTED WIND SPEED (mph)	LEVEE SLOPE	AVG FETCH DEPTH (ft)	WIND SET (ft)	RUNUP (ft)	SET + RUNUP (ft)
West Levee	Feb 17th	3.0	42	46	4:1	6.0	.76	2.11	2.87
East Levee	Feb 19th	3.8	24	29	3:1	12.0	.19	2.82	3.01
East Levee	Feb 20th	3.8	18	24	3:1	12.0	.13	2.36	2.49

2. DESIGN WIND-WAVE RUNUP ANALYSIS -

A. GENERAL - Design Wave runup calculations were performed for 5 locations in the Yolo Bypass. The first two locations are just south of the I-5 causeway. Location 1W is on the west side of the Yolo Bypass and 1E is on the east side. The next two locations are just south of the I-80 causeway. Location 2W is just south of the causeway on the west side of the Yolo Bypass and 2E is approximately 3.400 feet south of the causeway on the east side. The last site, site 3, is located on the east levee at the Lisbon gage.

B. WIND DATA - The historical wind data recorded at the Sacramento Executive Airport was used to determine the maximum wind speeds. Data from the months of November through April over the period 1950 to 1986 was sifted to come up with the maximum recorded windspeeds of 1-minute duration in each of six directions, North (N), Northwest (NW), South (S), Southwest (SW), Southwest (SW) and West (W). Table 13 shows the maximum recorded windspeeds.

TABLE 13

MAXIMUM WINDSPEEDS

DIRECTION	(mph)	MONTH	YEAR
N	44	FEB	1974
NW	43	FEB	1955
S	66	MAR	1952
SW	56	JAN	1959
SE	70	DEC	1952
W	40	FEB	1960

C. FETCH LENGTHS - The fetch length for each locationwas computed using effective fetch radials. The radials were fanned from the main fetch direction on three degree increments out to twelve degrees on each side of the main fetch direction.

D. DESIGN WINDS - The design windspeed for each location is different. The wind speed is dependent on the fetch length and direction. The design windspeeds on Table 14 were computed based on the criteria in ETL 1110-2-305.

E. WAVE CALCULATIONS - Wave heights and windset were calculated from criteria in ETL 1110-2-305. Wave runup was computed using criteria in Volume II of the US Army Coastal Engineering Research Center's Shore Protection Manual. Results are shown in Table 14.

TABLE 14

DESIGN WAVE HEIGHTS AND RUNUP

LOCATION	FETCH LENGTH (mi)	AVG FETCH DEPTH (ft)	DESIGN WIND SPEED (mph)	DIRECTION	DESIGN WSEL (ft)	LEVEE SLOPE	WIND SET (ft)	WAVE RUNUP (ft)	SET + RUNUP (ft)
1W	5.09	13.0	49.8	SE	31.0	3:1	.70	5.90	6.60
1E	2.0	13.0	42.0	SW	31.0	3:1	.20	3.30	3.50
2W	3.95	15.0	50.5	SE	25.6	3:1	.50	5.30	5.60
2E	6.36	15.0	39.0	SW	25.4	3:1	.50	5.10	5.60
3	8.26	13.0	38.5	SW	23.7	3:1	.70	5.20	5.90

TABLE 15

SACRAMENTO METRO STUDY
FLOWS AND STAGES
FREMONT SEDIMENT ELEVATION @ 31.0
WITH AND WITHOUT FAILURES IN FEATHER AND YUBA RIVERS

SACRAMENTO RIVER SYSTEM

COMMENT	FILENAME	FREMONT WEIR STAGE ft msl	FREMONT WEIR FLOW cfs	VERONA STAGE ft msl	VERONA FLOW cfs	SAC WEIR STAGE ft msl	SAC WEIR FLOW cfs	I-ST STAGE ft msl	I-ST FLOW cfs	FREEPORT STAGE ft msl	FREEPORT FLOW cfs
1986 OBSERVED		38.54	341000	39.11	92900	30.56	128000	30.58		25.11	117000
1986 COMPUTED	DMET863	38.9	341000	39.2	92900	30.3	124000	30.6	113000	24.9	113000
WITH FAILURES IN YUBA AND FEATHER RIVERS											
200 YEAR SAC 234 K ON AMER	DME32081	39	426000	39.6	95000	32	158000	33.1	126000	27.7	124000
400 YEAR SAC 234 K ON AMER	DME34081	39.1	438000	39.8	96000	32.1	160000	33.1	126000	27.7	124000
WITHOUT FAILURES IN YUBA AND FEATHER RIVERS											
200 YEAR SAC 234 K ON AMER	DME32083	39.5	471000	40.3	104000	32	159000	33.1	126000	27.7	124000
400 YEAR SAC 234 K ON AMER	DFEA40N8	41	610000	42.3	114000	32.4	170000	33.4	129000	28.1	126000

COMMENT	AMER RIVER H-STREET STAGE ft msl	NEMDC MAIN AVE STAGE ft msl	CROSS CANAL HIWAY 99 ft msl	FILENAME	YOLO BYPASS RIDGE CUT ft msl	YOLO BYPASS WOODLND ft msl	YOLO BYPASS D/S SAC BYPAS ft msl	YOLO BYPASS SHIP CHANL ft msl	YOLO BYPASS LISBN ft msl	SAC BYPAS MILE 1 ft msl	A	B	C	D	E	F	G	H	I	J	K	L
1986 OBSERVED	40.4	35.6	39.6		34	31.4	29.2	27.5	24.9	29.5est												
1986 COMPUTED	40.9	35.7	39.3	DY0863	33.9	31.5	29	27.3	24.9	29.7												
WITH FAILURES IN YUBA AND FEATHER RIVERS																						
200 YEAR SAC 234 K ON AMER	41.7	36.9	40.1	DY032081	35.9	33	30.5	28.7	25.9	31.3	X	X	X		X							
400 YEAR SAC 234 K ON AMER	41.7	36.9	40.3	DY034081	36.1	33.3	30.8	28.9	26	31.6	X	X	X		X							
WITHOUT FAILURES IN YUBA AND FEATHER RIVERS																						
200 YEAR SAC 234 K ON AMER	41.7	36.9	40.4	DY032083	36.6	33.6	30.9	29	26	31.5	X	X	X		X							
400 YEAR SAC 234 K ON AMER	41.7	36.9	42.4	DY0400N8	39.1	35.6	32.6	30.3	26.9	33.1	X	X	X		X							

------LEVEE FAILURE LOCATIONS------

A. RIGHT BANK AMERICAN RIVER ABOVE H-STREET
B. LEFT BANK AMERICAN RIVER MAYHEW DRAIN AREA
C. RIGHT BANK FLOW RETURN TO AMERICAN RIVER
D. RIGHT BANK AMERICAN RIVER BELOW NEMDC
E. RIGHT BANK SAC RIVER (AREA C)
F. WEST LEVEE NATOMAS EAST MAIN DRAIN
G. SOUTH LEVEE CROSS CANAL
H. WEST LEVEE SAC RIVER @ MILE 50
I. AREA C RETURN FLOW TO YOLO BYPASS
J. YOLO BYPASS U/S SAC BYPASS
K. YOLO BYPASS D/S SAC BYPASS
L. YOLO BYPASS U/S SHIP CHANNEL

----- COMPUTATIONAL POINT LOCATIONS -----

FREMONT WEIR - FREMONT WEIR WEST END
VERONA - SACRAMENTO RIVER AT VERONA
SAC WEIR - SACRAMENTO RIVER AT NORTH END OF THE SAC WEIR.
I-STREET - SACRAMENTO RIVER AT I-STREET
FREEPORT - SACRAMENTO RIVER AT FREEPORT
H-STREET - AMERICAN RIVER AT H-STREET
MAIN AVE - NEMDC JUST DOWNSTREAM OF DRY CREEK
HIWAY 99 - CROSS CANAL AT HIGHWAY 99 CROSSING
RIDGE CUT - YOLO BYPASS AT KNIGHTS LANDING RIDGE CUT
WOODLAND - YOLO BYPASS AT WOODLAND
D/S SAC BYPASS - YOLO BYPASS JUST DOWNSTREAM OF THE SACRAMENTO BYPASS
SHIP CHANNEL - YOLO BYPASS APPROXIMATELY 1 MILE DOWNSTREAM OF INTERSTATE 80
LISBON - YOLO BYPASS AT LISBON
SAC BYPASS - MIDPOINT BETWEEN SAC WEIR AND YOLO BYPASS

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JH 3/22/91

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TABLE 16
SACRAMENTO METRO STUDY
FLOWS AND STAGES
FREMONT SEDIMENT ELEVATION @ 31.0
AMERICAN AND SACRAMENTO RIVER CONCURRENCY SENSITIVITY

		SACRAMENTO RIVER SYSTEM										AMER RIVER	NEMDC	CROSS CANAL	YOLO BYPASS						SAC BYPAS	FAILURE LOCATIONS											
COMMENT	FILENAME	FREMONT WEIR STAGE ft msl	FREMONT WEIR FLOW cfs	VERONA STAGE ft msl	VERONA FLOW cfs	SAC WEIR STAGE ft msl	SAC WEIR FLOW cfs	I-ST STAGE ft msl	I-ST FLOW cfs	FREEPORT STAGE ft msl	FREEPORT FLOW cfs	H-STREET STAGE ft msl	MAIN AVE STAGE ft msl	HIWAY 99 ft msl	FILENAME	RIDGE CUT ft msl	WOODLND ft msl	D/S SAC BYPAS ft msl	SHIP CHANL ft msl	LISBN ft msl	MILE 1 ft msl	A	B	C	D	E	F	G	H	I	J	K	L
1986 OBSERVED		38.54	341000	39.11	92900	30.56	128000	30.58		25.11	117000	40.4	35.6	39.6		34	31.4	29.2	27.5	24.9	29.5est												
1986 COMPUTED	DMET863	38.9	341000	39.2	92900	30.3	124000	30.6	113000	24.9	113000	40.9	35.7	39.3	DY0863	33.9	31.5	29	27.3	24.9	29.7												
WITH CONCURRENT FLOW IN THE AMERICAN RIVER																																	
200 YEAR SAC 200 YEAR AMER	D200SAM	38.6	394000	38.8	130000	33.4	181000	35.8	142000	30.3	140000	43	38.1	39.4	DY200SAM	35.3	32.7	30.4	28.6	25.8	31.5	X	X	X	X	X	X						
400 YEAR SAC 400 YEAR AMER	D400SAM	38.7	406000	39	129000	34.1	196000	37	149000	31.4	148000	43.4	38.2	39.6	DY400SAM	25.7	33.1	30.8	28.9	26	32	X	X	X	X	X	X						
WITH 100 YEAR IN THE AMERICAN RIVER																																	
200 YEAR SAC 100 YEAR AMER	DME3208	38.4	384000	38.5	136000	31.5	146000	32.7	123000	27.3	121000	41.7	36.9	39.1	DY03208	35	32.3	29.8	28.1	25.5	30.6	X	X	X		X							
400 YEAR SAC 100 YEAR AMER	DME3408	38.6	394000	38.6	140000	31.6	147000	32.7	123000	27.3	122000	41.7	36.9	39.3	DY3408	35.2	32.5	30	28.3	25.6	30.8	X	X	X		X							

------LEVEE FAILURE LOCATIONS------
A. RIGHT BANK AMERICAN RIVER ABOVE H-STREET
B. LEFT BANK AMERICAN RIVER MAYHEW DRAIN AREA
C. RIGHT BANK FLOW RETURN TO AMERICAN RIVER
D. RIGHT BANK AMERICAN RIVER BELOW NEMDC
E. RIGHT BANK SAC RIVER (AREA C)
F. WEST LEVEE NATOMAS EAST MAIN DRAIN
G. SOUTH LEVEE CROSS CANAL
H. WEST LEVEE SAC RIVER @ MILE 50
I. AREA C RETURN FLOW TO YOLO BYPASS
J. YOLO BYPASS U/S SAC BYPASS
K. YOLO BYPASS D/S SAC BYPASS
L. YOLO BYPASS U/S SHIP CHANNEL

----- COMPUTATIONAL POINT LOCATIONS -----
FREMONT WEIR - FREMONT WEIR WEST END
VERONA - SACRAMENTO RIVER AT VERONA
SAC WEIR - SACRAMENTO RIVER AT NORTH END OF THE SAC WEIR.
I-STREET - SACRAMENTO RIVER AT I-STREET
FREEPORT - SACRAMENTO RIVER AT FREEPORT
H-STREET - AMERICAN RIVER AT H-STREET
MAIN AVE - NEMDC JUST DOWNSTREAM OF DRY CREEK
HIWAY 99 - CROSS CANAL AT HIGHWAY 99 CROSSING
RIDGE CUT - YOLO BYPASS AT KNIGHTS LANDING RIDGE CUT
WOODLAND - YOLO BYPASS AT WOODLAND
D/S SAC BYPASS - YOLO BYPASS JUST DOWNSTREAM OF THE SACRAMENTO BYPASS
SHIP CHANNEL - YOLO BYPASS APPROXIMATELY 1 MILE DOWNSTREAM OF INTERSTATE 80
LISBON - YOLO BYPASS AT LISBON
SAC BYPASS - MIDPOINT BETWEEN SAC WEIR AND YOLO BYPASS

NOTE:
THE FLOWS AND STAGES IN THE SACRAMENTO RIVER BELOW
THE AMERICAN RIVER FOR THE FILENAMES D200SAM
AND D400SAM SHOULD BE CONSIDERED HYPOTHETICAL
THESE FLOWS AND STAGES WOULD NEVER BE REACHED
SINCE LEVEES WOULD BE OVERTOPPED. THESE FLOWS AND STAGES
EQUATE TO INFINITELY HIGH LEVEES ON THE SACRAMENTO RIVER.
IT IS ALSO ASSUMED THAT THE SACRAMENTO WEIR CAN HANDLE
THE FLOWS SHOWN.

FILE SACK9
JH 4/3/91

A1-T67
U1-BL67

TABLE 17

SACRAMENTO METRO STUDY
FLOWS AND STAGES
PREPROJECT CONDITIONS (WITH FREEBOARD FAILURES)
FREMONT SEDIMENT ELEVATION @ 31.0
100 YEAR

		SACRAMENTO RIVER SYSTEM										AMER RIVER	NEMDC	CROSS CANAL		YOLO BYPASS					SAC BYPAS	FAILURE LOCATIONS											
COMMENT	FILENAME	FREMONT WEIR STAGE ft msl	FREMONT WEIR FLOW cfs	VERONA STAGE ft msl	VERONA FLOW cfs	SAC WEIR STAGE ft msl	SAC WEIR FLOW cfs	I-ST STAGE ft msl	I-ST FLOW cfs	FREEPORT STAGE ft msl	FREEPORT FLOW cfs	H-STREET STAGE ft msl	MAIN AVE STAGE ft msl	HIWAY 99 ft msl	FILENAME	RIDGE CUT ft msl	WOODLND ft msl	D/S SAC BYPAS ft msl	SHIP CHANL ft msl	LISBN ft msl	MILE 1 ft msl	A	B	C	D	E	F	G	H	I	J	K	L
1986 OBSERVED		38.54	341000	39.11	92900	30.56	128000	30.58		25.11	117000	40.4	35.6	39.6		34	31.4	29.2	27.5	24.9	29.5est												
1986 COMPUTED	DMEI863	38.9	341000	39.2	92900	30.3	124000	30.6	113000	24.9	113000	40.9	35.7	39.3	DY0863	33.9	31.5	29	27.3	24.9	29.7												
100 YR ON SAC 100 YR ON AMER	DME31081	38.5	386000	38.8	90000	31.7	153000	32.7	126000	27.4	122000	41.7	36.9	39.6	DY031081	35.1	32.4	30	28.2	25.6	30.8	X	X	X			X						
100 YR ON SAC 100 YR ON AMER	DME31081	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME	DYY31081	34.8	32	29.2	27.5	25.1	30.2	X	X	X			X					X	X
100 YR ON SAC 100 YR ON AMER	DME3108	38.1	358000	38.2	117000	31.4	144000	32.5	123000	27	120000	41.7	36.9	39	DY0310B	34.4	31.8	29.4	27.8	25.3	30.2	X	X	X		X	X						
100 YR ON SAC 100 YR ON AMER	DME3108	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME	DYR310B	34.4	31.8	29.4	27.8	25.3	30.3	X	X	X		X	X			X	X		
100 YR ON SAC 100 YR ON AMER	DME3108	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME	DYY310B	34.3	31.6	29	27.3	25	29.9	X	X	X		X	X			X	X	X	X
100 YR ON SAC 100 YR ON AMER	DWE3108	38.1	356000	38.2	120000	31.1	138000	31.9	151000	26	118000	SAME	SAME	SAME	DWY310C	34.2	31.5	28.9	27.3	25	29.5	X	X	X		X	X		X	X	X	X	X

------LEVEE FAILURE LOCATIONS------
A. RIGHT BANK AMERICAN RIVER ABOVE H-STREET
B. LEFT BANK AMERICAN RIVER MAYHEW DRAIN AREA
C. RIGHT BANK FLOW RETURN TO AMERICAN RIVER
D. RIGHT BANK AMERICAN RIVER BELOW NEMDC
E. RIGHT BANK SAC RIVER (AREA C)
F. WEST LEVEE NATOMAS EAST MAIN DRAIN
G. SOUTH LEVEE CROSS CANAL
H. WEST LEVEE SAC RIVER @ MILE 50
I. AREA C RETURN FLOW TO YOLO BYPASS
J. YOLO BYPASS U/S SAC BYPASS
K. YOLO BYPASS D/S SAC BYPASS
L. YOLO BYPASS U/S SHIP CHANNEL

----- COMPUTATIONAL POINT LOCATIONS -----
FREMONT WEIR - FREMONT WEIR WEST END
VERONA - SACRAMENTO RIVER AT VERONA
SAC WEIR - SACRAMENTO RIVER AT NORTH END OF THE SAC WEIR.
I-STREET - SACRAMENTO RIVER AT I-STREET
FREEPORT - SACRAMENTO RIVER AT FREEPORT
H-STREET - AMERICAN RIVER AT H-STREET
MAIN AVE - NEMDC JUST DOWNSTREAM OF DRY CREEK
HIWAY 99 - CROSS CANAL AT HIGHWAY 99 CROSSING
RIDGE CUT - YOLO BYPASS AT KNIGHTS LANDING RIDGE CUT
WOODLAND - YOLO BYPASS AT WOODLAND
D/S SAC BYPASS - YOLO BYPASS JUST DOWNSTREAM OF THE SACRAMENTO BYPASS
SHIP CHANNEL - YOLO BYPASS APPROXIMATELY 1 MILE DOWNSTREAM OF INTERSTATE 80
LISBON - YOLO BYPASS AT LISBON
SAC BYPASS - MIDPOINT BETWEEN SAC WEIR AND YOLO BYPASS

FILE SACK1
JN 5/16/90

A1-TS4
U1-BL54

TABLE 18

SACRAMENTO METRO STUDY
FLOWS AND STAGES

PREPROJECT CONDITIONS (WITH FREEBOARD FAILURES)
FREMONT SEDIMENT ELEVATION @ 31.0
200 YEAR

COMMENT	FILENAME	SACRAMENTO RIVER SYSTEM: FREMONT WEIR STAGE ft msl	FREMONT WEIR FLOW cfs	VERONA STAGE ft msl	VERONA FLOW cfs	SAC WEIR STAGE ft msl	SAC WEIR FLOW cfs	I-ST STAGE ft msl	I-ST FLOW cfs	FREEPORT STAGE ft msl	FREEPORT FLOW cfs	AMER RIVER: H-STREET STAGE ft msl	NEMDC: MAIN AVE STAGE ft msl	CROSS CANAL: HIWAY 99 ft msl	FILENAME	YOLO BYPASS: RIDGE CUT ft msl	WOODLND ft msl	D/S SAC BYPAS ft msl	SHIP CHANL ft msl	LISBN ft msl	SAC BYPAS: MILE 1 ft msl	FAILURE LOCATIONS A	B	C	D	E	F	G	H	I	J	K	L
1986 OBSERVED		38.54	341000	39.11	92900	30.56	128000	30.58		25.11	117000	40.4	35.6	39.6		34	31.4	29.2	27.5	24.9	29.5est												
1986 COMPUTED	DME1863	38.9	341000	39.2	92900	30.3	124000	30.6	113000	24.9	113000	40.9	35.7	39.3	DY0863	33.9	31.5	29	27.3	24.9	29.7												
100 YR ON SAC 200 YR ON AMER	DME32001	38.6	393000	39.3	91000	33.8	194000	36.2	146000	30.6	142000	43	38.1	39.8	DY032001	35.4	32.8	30.6	28.8	25.9	31.8	X	X	X	X		X						
100 YR ON SAC 200 YR ON AMER	DME3200	38.1	358000	38.3	120000	33.3	179000	35.8	143000	30.3	140000	43	38.1	39	DY0320D	34.6	32.1	29.9	28.2	25.6	31.1	X	X	X	X	X	X						
100 YR ON SAC 200 YR ON AMER	DME3200	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME	DYA3200	34.6	32.1	29.9	28.2	25.6	31.1	X	X	X	X	X	X			X	X		
100 YR ON SAC 200 YR ON AMER	DME3200	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME	DYY3200	34.4	31.7	29.2	27.5	25.1	30.6	X	X	X	X	X	X			X	X	X	X
100 YR ON SAC 200 YR ON AMER	DWE3200	38	353000	38.2	129000	32.1	156000	33.2	180000	25.6	125000	43	38.1	38.9	DWY3200C	34.1	31.6	29.2	27.4	25.1	30.1	X	X	X	X	X	X		X	X	X	X	X
200 YR ON SAC 100 YR ON AMER	DME32081	39	426000	39.6	95000	32	158000	33.1	126000	27.7	124000	41.7	36.9	40.1	DY032081	35.9	33	30.5	28.7	25.9	31.3	X	X	X		X							
200 YR ON SAC 100 YR ON AMER	DME32081	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME	DYY32081	35.6	32.6	29.7	27.8	25.3	30.6	X	X	X		X						X	X
200 YR ON SAC 100 YR ON AMER	DME3208	38.4	384000	38.5	136000	31.5	146000	32.7	123000	27.3	121000	41.7	36.9	39.1	DY03208	35	32.3	29.8	28.1	25.5	30.6	X	X	X		X	X						
200 YR ON SAC 100 YR ON AMER	DME3208	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME	DYA3208	35	32.3	29.8	28.1	25.5	30.6	X	X	X		X	X			X	X		
200 YR ON SAC 100 YR ON AMER	DME3208	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME	DYY3208	34.8	32	29.2	27.5	25.1	30.1	X	X	X		X	X			X	X	X	X
200 YR ON SAC 100 YR ON AMER	DWE3208	38.5	390000	38.5	140000	31.2	140000	32	151000	26	118000	41.7	36.9	39.3	DWY3208C	34.9	32	29.3	27.5	25.1	30	X	X	X		X	X		X	X	X	X	X

------LEVEE FAILURE LOCATIONS------
A. RIGHT BANK AMERICAN RIVER ABOVE H-STREET
B. LEFT BANK AMERICAN RIVER MAYHEW DRAIN AREA
C. RIGHT BANK FLOW RETURN TO AMERICAN RIVER
D. RIGHT BANK AMERICAN RIVER BELOW NEMDC
E. RIGHT BANK SAC RIVER (AREA C)
F. WEST LEVEE NATOMAS EAST MAIN DRAIN
G. SOUTH LEVEE CROSS CANAL
H. WEST LEVEE SAC RIVER @ MILE 50
I. AREA C RETURN FLOW TO YOLO BYPASS
J. YOLO BYPASS U/S SAC BYPASS
K. YOLO BYPASS D/S SAC BYPASS
L. YOLO BYPASS U/S SHIP CHANNEL

----- COMPUTATIONAL POINT LOCATIONS -----
FREMONT WEIR - FREMONT WEIR WEST END
VERONA - SACRAMENTO RIVER AT VERONA
SAC WEIR - SACRAMENTO RIVER AT NORTH END OF THE SAC WEIR.
I-STREET - SACRAMENTO RIVER AT I-STREET
FREEPORT - SACRAMENTO RIVER AT FREEPORT
H-STREET - AMERICAN RIVER AT H-STREET
MAIN AVE - NEMDC JUST DOWNSTREAM OF DRY CREEK
HIWAY 99 - CROSS CANAL AT HIGHWAY 99 CROSSING
RIDGE CUT - YOLO BYPASS AT KNIGHTS LANDING RIDGE CUT
WOODLAND - YOLO BYPASS AT WOODLAND
D/S SAC BYPASS - YOLO BYPASS JUST DOWNSTREAM OF THE SACRAMENTO BYPASS
SHIP CHANNEL - YOLO BYPASS APPROXIMATELY 1 MILE DOWNSTREAM OF INTERSTATE 80
LISBON - YOLO BYPASS AT LISBON
SAC BYPASS - MIDPOINT BETWEEN SAC WEIR AND YOLO BYPASS

FILE SACK2
JH 5/16/90

A1-164
U1-BL64

TABLE 19

SACRAMENTO METRO STUDY
FLOWS AND STAGES
PREPROJECT CONDITIONS (WITH FREEBOARD FAILURES)
FREMONT SEDIMENT ELEVATION @ 31.0
400 YEAR

		SACRAMENTO RIVER SYSTEM										AMER RIVER	NEMDC	CROSS CANAL	YOLO BYPASS						SAC BYPAS	FAILURE LOCATIONS											
COMMENT	FILENAME	FREMONT WEIR STAGE ft msl	FREMONT WEIR FLOW cfs	VERONA STAGE ft msl	VERONA FLOW cfs	SAC WEIR STAGE ft msl	SAC WEIR FLOW cfs	I-ST STAGE ft msl	I-ST FLOW cfs	FREEPORT STAGE ft msl	FREEPORT FLOW cfs	H-STREET STAGE ft msl	MAIN AVE STAGE ft msl	HIWAY 99 ft msl	FILENAME	RIDGE CUT ft msl	WOODLND ft msl	D/S SAC BYPAS ft msl	SHIP CHANL ft msl	LISBN ft msl	MILE 1 ft msl	A	B	C	D	E	F	G	H	I	J	K	L
1986 OBSERVED		38.54	341000	39.11	92900	30.56	128000	30.58		25.11	117000	40.4	35.6	39.6		34	31.4	29.2	27.5	24.9	29.5est												
1986 COMPUTED	DMET863	38.9	341000	39.2	92900	30.3	124000	30.6	113000	24.9	113000	40.9	35.7	39.3	DY0863	33.9	31.5	29	27.3	24.9	29.7												
100 YR ON SAC 400 YR ON AMER	DME340F1	38.6	398000	39.3	92000	34.6	208000	37.3	150000	31.7	150000	43.2	38.2	39.8	DY0340F1	35.5	33	30.9	29	26.1	32.2	X	X	X	X		X						
100 YR ON SAC 400 YR ON AMER	DME340F	38.1	359000	38.3	117000	34	191000	36.9	149000	31.3	147000	43.2	38.2	39	DY0340F	34.6	32.3	30.2	28.4	25.7	31.4	X	X	X	X	X	X						
100 YR ON SAC 400 YR ON AMER	DME340F	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME	DYA340F	34.7	32.3	30.1	28.4	25.7	31.4	X	X	X	X	X	X			X	X		
100 YR ON SAC 400 YR ON AMER	DME340F	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME	DYY340F	34.4	31.8	29.4	27.5	25.2	30.8	X	X	X	X	X	X			X	X	X	X
100 YR ON SAC 400 YR ON AMER	DWE340F	38.1	355000	38.2	126000	32.4	161000	33.4	191000	25.9	131000	43.2	38.2	39	DWY340FC	34.3	31.7	29.3	27.5	25.1	30.3	X	X	X	X	X	X		X	X	X	X	X
400 YR ON SAC 100 YR ON AMER	DME340B1	39.1	438000	39.8	96000	32.1	160000	33.2	126000	27.8	124000	41.7	36.9	40.3	DY0340B1	36.1	33.3	30.8	28.9	26	31.6	X	X	X			X						
400 YR ON SAC 100 YR ON AMER	DME340B1	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME	DYY340B1	35.9	32.8	29.9	28	25.4	30.9	X	X	X			X					X	X
400 YR ON SAC 100 YR ON AMER	DME340B	38.6	394000	38.6	140000	31.6	147000	32.7	123000	27.3	122000	41.7	36.9	39.3	DY0340B	35.2	32.5	30	28.3	25.6	30.8	X	X	X		X	X						
400 YR ON SAC 100 YR ON AMER	DME340B	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME	DYA340B	35.2	32.5	30	28.2	25.6	30.8	X	X	X		X	X			X	X		
400 YR ON SAC 100 YR ON AMER	DME340B	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME	DYY340B	35	32.2	29.2	27.4	25.1	30.1	X	X	X		X	X			X	X	X	X
400 YR ON SAC 100 YR ON AMER	DWE340B	38.5	390000	38.5	140000	31.2	139000	32	155000	26	118000	41.7	36.9	39.3	DWY340C	35	32.2	29.4	27.6	25.2	30.2	X	X	X		X	X		X	X	X	X	X

------LEVEE FAILURE LOCATIONS------
A. RIGHT BANK AMERICAN RIVER ABOVE H-STREET
B. LEFT BANK AMERICAN RIVER MAYHEW DRAIN AREA
C. RIGHT BANK FLOW RETURN TO AMERICAN RIVER
D. RIGHT BANK AMERICAN RIVER BELOW NEMDC
E. RIGHT BANK SAC RIVER (AREA C)
F. WEST LEVEE NATOMAS EAST MAIN DRAIN
G. SOUTH LEVEE CROSS CANAL
H. WEST LEVEE SAC RIVER @ MILE 50
I. AREA C RETURN FLOW TO YOLO BYPASS
J. YOLO BYPASS U/S SAC BYPASS
K. YOLO BYPASS D/S SAC BYPASS
L. YOLO BYPASS U/S SHIP CHANNEL

----- COMPUTATIONAL POINT LOCATIONS -----
FREMONT WEIR - FREMONT WEIR WEST END
VERONA - SACRAMENTO RIVER AT VERONA
SAC WEIR - SACRAMENTO RIVER AT NORTH END OF THE SAC WEIR.
I-STREET - SACRAMENTO RIVER AT I-STREET
FREEPORT - SACRAMENTO RIVER AT FREEPORT
H-STREET - AMERICAN RIVER AT H-STREET
MAIN AVE - NEMDC JUST DOWNSTREAM OF DRY CREEK
HIWAY 99 - CROSS CANAL AT HIGHWAY 99 CROSSING
RIDGE CUT - YOLO BYPASS AT KNIGHTS LANDING RIDGE CUT
WOODLAND - YOLO BYPASS AT WOODLAND
D/S SAC BYPASS - YOLO BYPASS JUST DOWNSTREAM OF THE SACRAMENTO BYPASS
SHIP CHANNEL - YOLO BYPASS APPROXIMATELY 1 MILE DOWNSTREAM OF INTERSTATE 80
LISBON - YOLO BYPASS AT LISBON
SAC BYPASS - MIDPOINT BETWEEN SAC WEIR AND YOLO BYPASS

FILE SACK3
JN 5/16/90

AI-T64
UI-BL64

TABLE 19

TABLE 20

SACRAMENTO METRO STUDY
FLOWS AND STAGES
WITH AREA C & RIVER MILE 50 FREEBOARD FAILURES
WITH RETURN FLOW TO YOLO BYPASS
WITH AND WITHOUT YOLO BYPASS FREEBOARD FAILURES
FREMONT SEDIMENT ELEVATION @ 31.0

		SACRAMENTO RIVER SYSTEM										AMER RIVER	NEMDC	CROSS CANAL
COMMENT	FILENAME	FREMONT WEIR STAGE ft msl	FREMONT WEIR FLOW cfs	VERONA STAGE ft msl	VERONA FLOW cfs	SAC WEIR STAGE ft msl	SAC WEIR FLOW cfs	I-ST STAGE ft msl	I-ST FLOW cfs	FREEPORT STAGE ft msl	FREEPORT FLOW cfs	H-STREET STAGE ft msl	MAIN AVE STAGE ft msl	HIWAY 99 ft msl
100 YR ON SAC 100 YR ON AMER	DWE310B	38.1	356000	38.2	120000	31.1	138000	31.9	151000	26	118000	41.7	36.9	39
100 YR ON SAC 100 YR ON AMER	DWE310B	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME
200 YR ON SAC 100 YR ON AMER	DWE320B	38.4	390000	38.5	140000	31.2	140000	32	153000	26	118000	41.7	36.9	39.3
200 YR ON SAC 100 YR ON AMER	DWE320B	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME
100 YR ON SAC 200 YR ON AMER	DWE320D	38	353000	38.2	129000	32.1	156000	33.2	180000	25.6	125000	41.7	36.9	38.9
100 YR ON SAC 200 YR ON AMER	DWE320D	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME

	YOLO BYPASS						SAC BYPAS	FAILURE LOCATIONS											
COMMENT	FILENAME	RIDGE CUT ft msl	WOOLND ft msl	D/S SAC BYPAS ft msl	SHIP CHANL ft msl	LISBN ft msl	MILE 1 ft msl	A	B	C	D	E	F	G	H	I	J	K	L
100 YR ON SAC 100 YR ON AMER	DWY310C	34.2	31.5	28.9	27.3	25	29.5	X	X	X		X	X		X	X	X	X	X
100 YR ON SAC 100 YR ON AMER	DWA310B	34.4	31.8	29.4	27.7	25.3	29.9	X	X	X		X	X		X	X	X		
200 YR ON SAC 100 YR ON AMER	DWY320BC	34.9	32	29.3	27.5	25.1	30	X	X	X		X	X		X	X	X	X	X
200 YR ON SAC 100 YR ON AMER	DWA320B	35.2	32.5	30.1	28.4	25.7	30.6	X	X	X		X	X		X	X	X		
100 YR ON SAC 200 YR ON AMER	DWY320DC	34.1	31.6	29.2	27.4	25.1	30.1	X	X	X	X	X	X		X	X	X	X	X
100 YR ON SAC 200 YR ON AMER	DWA320D	34.3	31.9	29.7	28	25.5	30.5	X	X	X	X	X	X		X	X	X		

------LEVEE FAILURE LOCATIONS------
A. RIGHT BANK AMERICAN RIVER ABOVE H-STREET
B. LEFT BANK AMERICAN RIVER MAYHEW DRAIN AREA
C. RIGHT BANK FLOW RETURN TO AMERICAN RIVER
D. RIGHT BANK AMERICAN RIVER BELOW NEMDC
E. RIGHT BANK SAC RIVER (AREA C)
F. WEST LEVEE NATOMAS EAST MAIN DRAIN
G. SOUTH LEVEE CROSS CANAL
H. WEST LEVEE SAC RIVER(@ MILE 50)
I. AREA C RETURN FLOW TO YOLO BYPASS
J. YOLO BYPASS U/S SAC BYPASS
K. YOLO BYPASS D/S SAC BYPASS
L. YOLO BYPASS U/S SHIP CHANNEL

----- COMPUTATIONAL POINT LOCATIONS -----
FREMONT WEIR - FREMONT WEIR WEST END
VERONA - SACRAMENTO RIVER AT VERONA
SAC WEIR - SACRAMENTO RIVER AT NORTH END OF THE SAC WEIR.
I-STREET - SACRAMENTO RIVER AT I-STREET
FREEPORT - SACRAMENTO RIVER AT FREEPORT
H-STREET - AMERICAN RIVER AT H-STREET
MAIN AVE - NEMDC JUST DOWNSTREAM OF DRY CREEK
HIWAY 99 - CROSS CANAL AT HIGHWAY 99 CROSSING
RIDGE CUT - YOLO BYPASS AT KNIGHTS LANDING RIDGE CUT
WOODLAND - YOLO BYPASS AT WOODLAND
D/S SAC BYPASS - YOLO BYPASS JUST DOWNSTREAM OF THE SACRAMENTO BYPASS
SHIP CHANNEL - YOLO BYPASS APPROXIMATELY 1 MILE DOWNSTREAM OF INTERSTATE 80
LISBON - YOLO BYPASS AT LISBON
SAC BYPASS - MIDPOINT BETWEEN SAC WEIR AND YOLO BYPASS

FILE SACK4
JH 4/6/90

A1-TSD
W1-BL50

TABLE 21

SACRAMENTO METRO STUDY
FLOWS AND STAGES
WITH AREA C FREEBOARD FAILURES AND RETURN FLOW TO YOLO BYPASS
WITH AND WITHOUT YOLO BYPASS FREEBOARD FAILURES
FREMONT SEDIMENT ELEVATION @ 31.0

		SACRAMENTO RIVER SYSTEM										AMER RIVER	NEMDC	CROSS CANAL	YOLO BYPASS						SAC BYPAS												
COMMENT	FILENAME	FREMONT WEIR STAGE ft msl	FREMONT WEIR FLOW cfs	VERONA STAGE ft msl	VERONA FLOW cfs	SAC WEIR STAGE ft msl	SAC WEIR FLOW cfs	I-ST STAGE ft msl	I-ST FLOW cfs	FREEPORT STAGE ft msl	FREEPORT FLOW cfs	H-STREET STAGE ft msl	MAIN AVE STAGE ft msl	HIWAY 99 ft msl	FILENAME	RIDGE CUT ft msl	WOODLND ft msl	D/S SAC BYPAS ft msl	SHIP CHANL ft msl	LISBN ft msl	MILE 1 ft msl	FAILURE LOCATIONS A	B	C	D	E	F	G	H	I	J	K	L
100 YR ON SAC 115 K IN AMER	DME510B	38.1	355000	38.2	120000	29.4	107000	29.6	106000	24.3	105000	39.2	35.3	39	DY0510BC	34.3	31.7	29.3	27.7	25.3	29.8					X				X	X		
100 YR ON SAC 115 K IN AMER	DME510B	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME	DWY510BC	34.1	31.4	28.9	27.2	25	29.4					X				X	X	X	X
200 YR ON SAC 115 K IN AMER	DME520B	38.4	381000	38.4	140000	29.4	107000	29.6	106000	24.3	105008	39.2	35.3	39.1	DY0520BC	34.9	32.2	29.8	28.1	25.5	30.3					X				X	X		
200 YR ON SAC 115 K IN AMER	DME520B	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME	DWY520BC	34.7	31.9	29.2	27.5	25.1	29.7					X				X	X	X	X
400 YR ON SAC 115 K IN AMER	DME540B	38.5	391000	38.5	140000	29.4	107000	29.6	106000	24.3	105000	39.2	35.3	39.3	DY0540BC	35.2	32.5	30.2	28.4	25.7	30.6					X				X	X		
400 YR ON SAC 115 K IN AMER	DME540B	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME	DWY540BC	34.9	32.1	29.3	27.5	25.2	29.8					X				X	X	X	X
100 YR ON SAC 130 K IN AMER	DME610B	38.1	355000	38.2	120000	30	117000	30.4	110000	25	109000	40.5	35.8	39	DY0610BC	34.3	31.8	29.5	27.8	25.3	30.1					X				X	X		
100 YR ON SAC 130 K IN AMER	DME610B	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME	DWY610BC	34.2	31.5	29	27.4	25.1	29.6					X				X	X	X	X
100 YR ON SAC 180 K IN AMER	DME710C	38.1	358000	38.3	121000	31.6	147000	32.8	123000	27.4	121000	41.2	36.5	39	DY0710CC	34.5	32	29.9	28.2	25.5	30.7					X				X	X		
100 YR ON SAC 180 K IN AMER	DME710C	SAME		SAME		SAME		SAME		SAME		SAME	SAME	SAME	DWY710CC	34.3	31.7	29.2	27.4	25.1	30.1					X				X	X	X	X

------LEVEE FAILURE LOCATIONS------
A. RIGHT BANK AMERICAN RIVER ABOVE H-STREET
B. LEFT BANK AMERICAN RIVER MAYHEW DRAIN AREA
C. RIGHT BANK FLOW RETURN TO AMERICAN RIVER
D. RIGHT BANK AMERICAN RIVER BELOW NEMDC
E. RIGHT BANK SAC RIVER (AREA C)
F. WEST LEVEE NATOMAS EAST MAIN DRAIN
G. SOUTH LEVEE CROSS CANAL
H. WEST LEVEE SAC RIVER(@ MILE 50)
I. AREA C RETURN FLOW TO YOLO BYPASS
J. YOLO BYPASS U/S SAC BYPASS
K. YOLO BYPASS D/S SAC BYPASS
L. YOLO BYPASS U/S SHIP CHANNEL

----- COMPUTATIONAL POINT LOCATIONS -----
FREMONT WEIR - FREMONT WEIR WEST END
VERONA - SACRAMENTO RIVER AT VERONA
SAC WEIR - SACRAMENTO RIVER AT NORTH END OF THE SAC WEIR.
I-STREET - SACRAMENTO RIVER AT I-STREET
FREEPORT - SACRAMENTO RIVER AT FREEPORT
H-STREET - AMERICAN RIVER AT H-STREET
MAIN AVE - NEMDC JUST DOWNSTREAM OF DRY CREEK
HIWAY 99 - CROSS CANAL AT HIGHWAY 99 CROSSING
RIDGE CUT - YOLO BYPASS AT KNIGHTS LANDING RIDGE CUT
WOODLAND - YOLO BYPASS AT WOODLAND
D/S SAC BYPASS - YOLO BYPASS JUST DOWNSTREAM OF THE SACRAMENTO BYPASS
SHIP CHANNEL - YOLO BYPASS APPROXIMATELY 1 MILE DOWNSTREAM OF INTERSTATE 80
LISBON - YOLO BYPASS AT LISBON
SAC BYPASS - MIDPOINT BETWEEN SAC WEIR AND YOLO BYPASS

FILE SACKS
JH 4/7/90

A1-I55
U1-BL55

TABLE 22

SACRAMENTO METRO STUDY
FLOWS AND STAGES
OVERTOP FAILURE ONLY WITH SAC WEIR SENSITIVITY
FREMONT SEDIMENT ELEVATION @ 31.0

		SACRAMENTO RIVER SYSTEM										AMER RIVER	NEMOC	CROSS CANAL	YOLO BYPASS						SAC BYPAS						
COMMENT	FILENAME	FREMONT WEIR STAGE ft msl	FREMONT WEIR FLOW cfs	VERONA STAGE ft msl	VERONA FLOW cfs	SAC WEIR STAGE ft msl	SAC WEIR FLOW cfs	I-ST STAGE ft msl	I-ST FLOW cfs	FREEPORT STAGE ft msl	FREEPORT FLOW cfs	H-STREET STAGE ft msl	MAIN AVE STAGE ft msl	HIWY 99 ft msl	FILENAME	RIDGE CUT ft msl	WOODLND ft msl	D/S SAC BYPAS ft msl	SHIP CHANL ft msl	LISBN ft msl	MILE 1 ft msl	FAILURE LOCATIONS A	B	C	D	E	F
100 YR ON SAC 180K ON AMER	DME81081	38.5	387000	39.1	90000	31.6	150000	32.6	121000	27.2	120000	43.2	37.1	39.6	DY081081	35.1	32.4	30	28.3	25.6	30.8		X				
100 YR ON SAC 231K ON AMER	DME81082	38.5	386000	39.1	89000	31.8	153000	32.8	124000	27.4	122000	43.6	37.2	39.6	DY081082	35.1	32.4	30	28.3	25.6	30.8	X	X				
200 YR ON SAC 231K ON AMER	DME82081	39	425000	39.7	96000	31.9	156000	32.9	124000	27.5	122000	43.6	37.2	40.1	DY082081	35.8	33	30.5	28.7	25.9	31.3	X	X				
100 YR ON SAC 200 YR IN AMER	*DME82082*	*38.6*	*393000*	*39.2*	*88000*	*33.7*	*190000*	*35.8*	*152000*	*30.3*	*140000*	*44.1*	*38*	*39.8*	*DY082082*	*35.4*	*32.8*	*30.5*	*28.7*	*25.9*	*31.7*	X	X	X	X		X
100 YR ON SAC 150K ON AMER	DME81089	38.4	386000	39	89000	31.2	141000	31.9	118000	26.5	117000	42.4	36.4	39.6	DY081089	35	32.3	29.9	28.1	25.5	30.6						
100 YR ON SAC 115K ON AMER	DME51081	38.4	383000	38.9	92000	29.8	115000	30	107000	24.7	107000	39.2	35.3	39.6	DY051081	34.8	32.1	29.5	27.8	25.3	30						
200 YR ON SAC 115K ON AMER	DME52081	38.9	421000	39.6	97000	29.9	118000	30.2	108000	24.8	108000	39.2	35.3	40	DY052081	35.6	32.7	30	28.3	25.6	30.6						
400 YR ON SAC 115K ON AMER	DME54081	39	433000	39.7	97000	30	119000	30.2	109000	24.8	108000	39.2	35.3	40.2	DY054081	35.9	32.9	30.2	28.5	25.7	30.8						
100 YR ON SAC 200 YR ON AMER SAC WEIR @ 21.0 NO BOARDS	*DME82083*	*38.5*	*392000*	*39.2*	*89000*	*33.3*	*193000*	*35.7*	*151000*	*30.1*	*138000*	*44.1*	*38*	*39.7*	*DY082083*	*35.4*	*32.8*	*30.6*	*28.7*	*25.9*	*31.8*	X	X	X	X		X
100 YR ON SAC 200 YR ON AMER SAC WEIR @ 20.0 NO BOARDS	DME82084	38.5	390000	39.1	91000	32.5	199000	35.2	149000	29.7	136000	44.1	38	39.7	DY0820840	35.3	32.8	30.6	28.8	25.9	31.8	X	X	X	X		X

------LEVEE FAILURE LOCATIONS------
A. RIGHT BANK AMERICAN RIVER ABOVE H-STREET
B. LEFT BANK AMERICAN RIVER MAYHEW DRAIN AREA
C. RIGHT BANK FLOW RETURN TO AMERICAN RIVER
D. RIGHT BANK AMERICAN RIVER BELOW NEMDC
E. RIGHT BANK SAC RIVER (AREA C)
F. WEST LEVEE NATOMAS EAST MAIN DRAIN

----- COMPUTATIONAL POINT LOCATIONS -----
FREMONT WEIR - FREMONT WEIR WEST END
VERONA - SACRAMENTO RIVER AT VERONA
SAC WEIR - SACRAMENTO RIVER AT NORTH END OF THE SAC WEIR.
I-STREET - SACRAMENTO RIVER AT I-STREET
FREEPORT - SACRAMENTO RIVER AT FREEPORT
H-STREET - AMERICAN RIVER AT H-STREET
MAIN AVE - NEMDC JUST DOWNSTREAM OF DRY CREEK
HIWAY 99 - CROSS CANAL AT HIGHWAY 99 CROSSING
RIDGE CUT - YOLO BYPASS AT KNIGHTS LANDING RIDGE CUT
WOODLAND - YOLO BYPASS AT WOODLAND
D/S SAC BYPASS - YOLO BYPASS JUST DOWNSTREAM OF THE SACRAMENTO BYPASS
SHIP CHANNEL - YOLO BYPASS APPROXIMATELY 1 MILE DOWNSTREAM OF INTERSTATE 80
LISBON - YOLO BYPASS AT LISBON
SAC BYPASS - MIDPOINT BETWEEN SAC WEIR AND YOLO BYPASS

FILE SACK6
JH 4/19/90

AI-IS2
UI-BAS2

TABLE 23

SACRAMENTO METRO STUDY
FLOWS AND STAGES
PREPROJECT CONDITIONS (WITH FREEBOARD FAILURES)
FREMONT SEDIMENT ELEVATION @ 30.5

		SACRAMENTO RIVER SYSTEM										AMER RIVER	NEMDC	CROSS CANAL		YOLO BYPASS					SAC BYPAS	FAILURE LOCATIONS						
COMMENT	FILENAME	FREMONT WEIR STAGE ft msl	FREMONT WEIR FLOW cfs	VERONA STAGE ft msl	VERONA FLOW cfs	SAC WEIR STAGE ft msl	SAC WEIR FLOW cfs	I-ST STAGE ft msl	I-ST FLOW cfs	FREEPORT STAGE ft msl	FREEPORT FLOW cfs	H-STREET STAGE ft msl	MAIN AVE STAGE ft msl	HIWAY 99 ft msl	FILENAME	RIDGE CUT ft msl	WOOLND ft msl	D/S SAC BYPAS ft msl	SHIP CANAL ft msl	LISBN ft msl	MILE 1 ft msl	A	B	C	D	E	F	G
100 YR ON SAC 100 YR ON AMER WITH CROSS CANAL FAILURE	DXE7100	38	390000	38.7	87000	31.6	150000	32.7	126000	27.3	121000	41.7	36.9	39.3	DYX7100	35.1	32.4	29.9	28.2	25.6	30.7	X	X	X			X	
200 YR ON SAC 100 YR ON AMER WITH CROSS CANAL FAILURE	DXE7200	38.2	409000	38.9	115000	31.9	154000	33	128000	27.6	123000	41.7	36.9	39.4	DYX7200	35.5	32.8	30.3	28.5	25.8	31.1	X	X	X			X	X
400 YR ON SAC 100 YR ON AMER WITH CROSS CANAL FAILURE	DXE7400	38.4	419000	38.9	117000	31.9	156000	33	128000	27.6	123000	41.7	36.9	39.5	DYX7400	35.7	33	30.4	28.6	25.8	31.3	X	X	X			X	X

------LEVEE FAILURE LOCATIONS------
A. RIGHT BANK AMERICAN RIVER ABOVE H-STREET
B. LEFT BANK AMERICAN RIVER MAYHEW DRAIN AREA
C. RIGHT BANK FLOW RETURN TO AMERICAN RIVER
D. RIGHT BANK AMERICAN RIVER BELOW NEMDC
E. RIGHT BANK SAC RIVER (AREA C)
F. WEST LEVEE NATOMAS EAST MAIN DRAIN
G. SOUTH LEVEE CROSS CANAL

----- COMPUTATIONAL POINT LOCATIONS -----
FREMONT WEIR - FREMONT WEIR WEST END (LOCATION 37 ON CHART 1).
VERONA - SACRAMENTO RIVER AT VERONA (LOCATION 34 ON CHART 1).
SAC WEIR - SACRAMENTO RIVER AT NORTH END OF THE SAC WEIR.
I-STREET - SACRAMENTO RIVER AT I-STREET (LOCATION 46 ON CHART 1).
FREEPORT - SACRAMENTO RIVER AT FREEPORT (LOCATION 47 ON CHART 1).
H-STREET - AMERICAN RIVER AT H-STREET (LOCATION 45 ON CHART 1).
MAIN AVE - NEMDC JUST DOWNSTREAM OF DRY CREEK
HIWAY 99 - CROSS CANAL AT HIGHWAY 99 CROSSING
RIDGE CUT - YOLO BYPASS AT KNIGHTS LANDING RIDGE CUT (NEAR LOCATION 39 ON CHART 1)
WOODLAND - YOLO BYPASS AT WOODLAND (LOCATION 40 ON CHART 1).
D/S SAC BYPASS - YOLO BYPASS JUST DOWNSTREAM OF THE SACRAMENTO BYPASS
SHIP CHANNEL - YOLO BYPASS APPROXIMATELY 1 MILE DOWNSTREAM OF INTERSTATE 80.I
LISBON - YOLO BYPASS AT LISBON (LOCATION 50 ON CHART 1).
SAC BYPASS - MIDPOINT BETWEEN SAC WEIR AND YOLO BYPASS

FILE SAC20
JH 7/10/90

A1-T40
U1-BB40

REFERENCES

A. Mr. James Goodridge, Retired State of California Climatologist

B. NOAA ATLAS 2, Volume XI, California

C. Standard Project Criteria for General Rain Storms, April 1971, preliminary

D. Dry Creek, Placer and Sacramento Counties, Hydrology Office Report, July 1984, revised April 1988

E. Sacramento County and Sacramento City, California, Flood Insurance Study, Hydrology Internal Office Report, January 1975.

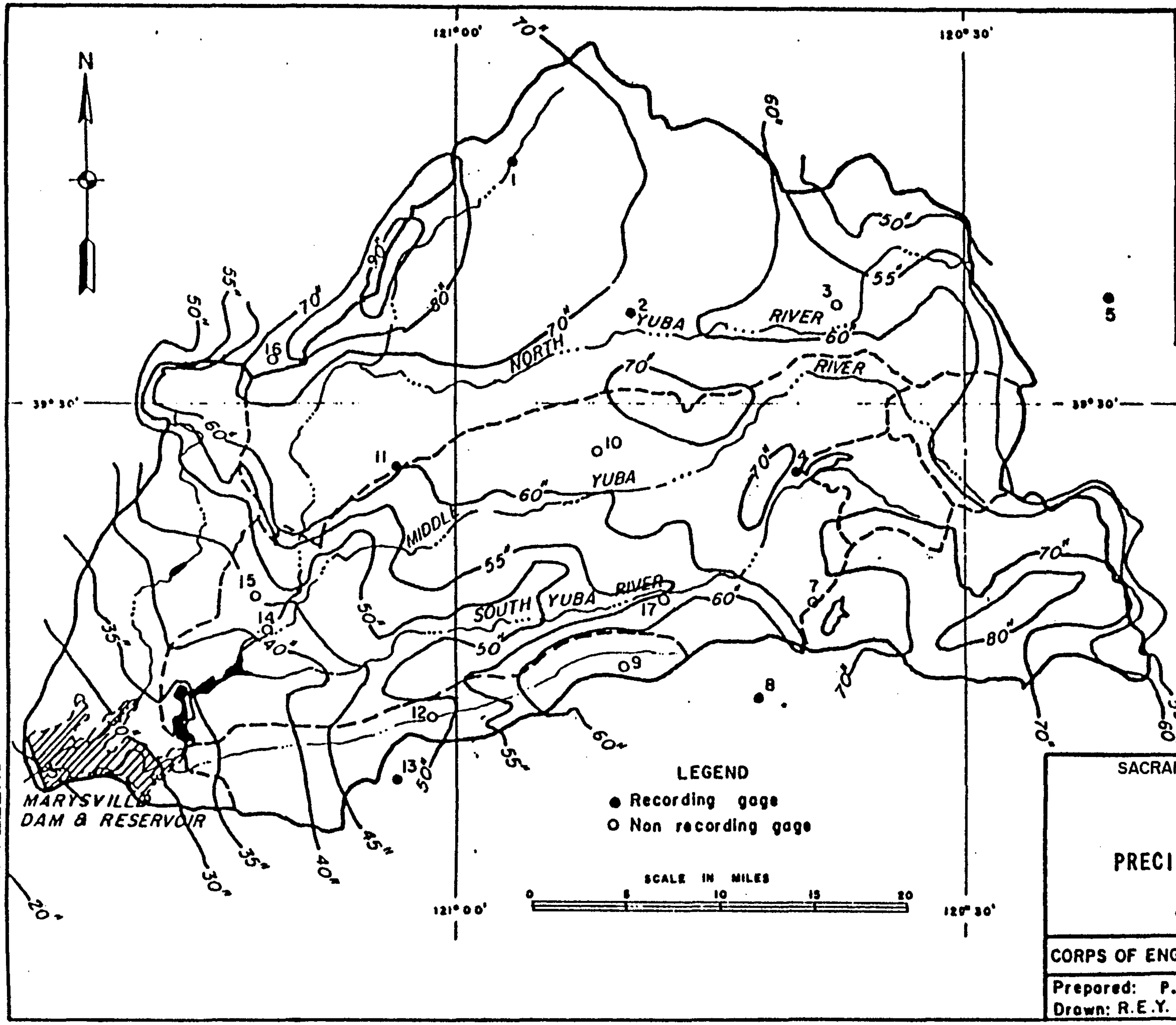
F. Special Study on the Lower American River, California March 1987

G. Morrison Creek Streamgroup, California, Hydrology Design Memorandum, July 1985

H. Hydrometeorological Report No. 36, Interim Report Probable Maximum Precipitation In California

I. American River and Sacramento Metro Investigations, California, January 1990

PLATES AND CHARTS



No	STATION NAME
1	LA PORTE
2	DOWNIEVILLE
3	SIERRA CITY
4	BOWMAN DAM
5	SIERRAVILLE R.S.
6	TRUCKEE R.S.
7	FULLER LAKE
8	BLUE CANYON
9	DEER CREEK P.H.
10	ALLEGHANY
11	CAMPTONVILLE
12	NEVADA CITY
13	GRASS VALLEY
14	COLGATE POWER HOUSE
15	DOBBINS
16	WOODLEAF
17	WASHINGTON

SACRAMENTO METRO INVESTIGATION

NORMAL ANNUAL
PRECIPITATION & HYDROLOGIC
STATIONS MAP

YUBA RIVER BASIN

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: P.W. - E.G.C. Date: JUNE 1990
Drawn: R.E.Y. & B.J.C.

LEGEND:

- Drainage Boundary
- —5— Contour in 1,000 feet (screened lines)
- —45— MAP Isohyet amount in inches
- ● Recording
- ○ Non-Recording
- ◐ Both Types

PRECIPITATION STATIONS

NO.	DESCRIPTION	NO.	DESCRIPTION
1	+ Tahoe Vista	40	Aerojet
2	+ Tahoe City	41	Represa
3	+ Squaw Valley	42	Folsom Dam
4	+ Donner Mem. St. Park	43	Long Valley Orch.
5	+ Soda Springs 1E	44	Shingle Springs
6	+ Onion Creek	45	El Dorado FFS
7	+ The Cedars	46	Diamond Springs
8	+ Talbot Camp	47	Placerville
9	+ Robertson Flat	48	Placerville 1W
10	+ Big Bend R.S.	49	Coloma
11	+ Westville	50	Garden Valley
12	+ Drum Forebay	51	Greenwood 1SE
13	+ Blue Canyon	52	+ Paradise Valley
14	+ Lake Spaulding	53	+ Applegate
15	+ Fuller Lake	54	+ Foresthill R.S.
16	+ Washington	55	+ Todd Valley
17	+ Deer Cr. P.H.	56	+ Volcanoville
18	+ Washington Ridge Camp	57	+ Georgetown
19	+ Gold Run	58	+ Georgetown R.S.
20	+ Bear R. Head Dam	59	Placerville IFG
21	+ Colfax	60	Mt. Danaher
22	+ Colfax F.S.	61	Camino Driver
23	+ Weimar 1W	62	Sly Park
24	+ Hidden Valley Rch.	63	Pacific House
25	+ Bear R. Rch.	64	Fresh Pond
26	+ Coon Cr.	65	El Dorado P.H.
27	+ Lincoln 6ENE	66	Jaybird P.H.
28	Newcastle Fowler	67	+ Blodgett Exp. Forest
29	+ KAHI Radio Sta.	68	+ Michigan Bluff
30	+ Cool	69	+ Brushy Spr. G.S.
31	+ Auburn Div. Forestry	70	+ Gerle Creek Camp
32	+ Auburn	71	Union Valley
33	+ Werner Rch.	72	Peavine Ridge
34	Loomis 2NW	73	Wright's Lake
35	Club Rch.	74	Kyburz Strawberry
36	Loomis	75	Twin Lakes
37	Rocklin	76	Meyers 4SW
38	Orangevale Moirao	77	Meyers R.S.
39	Orangevale Beach	78	Meyers Insp. Sta.
		79	D.L. Bliss State Park

+ Stations shown on this map.

SCALE 5 0 5 (Miles)

N

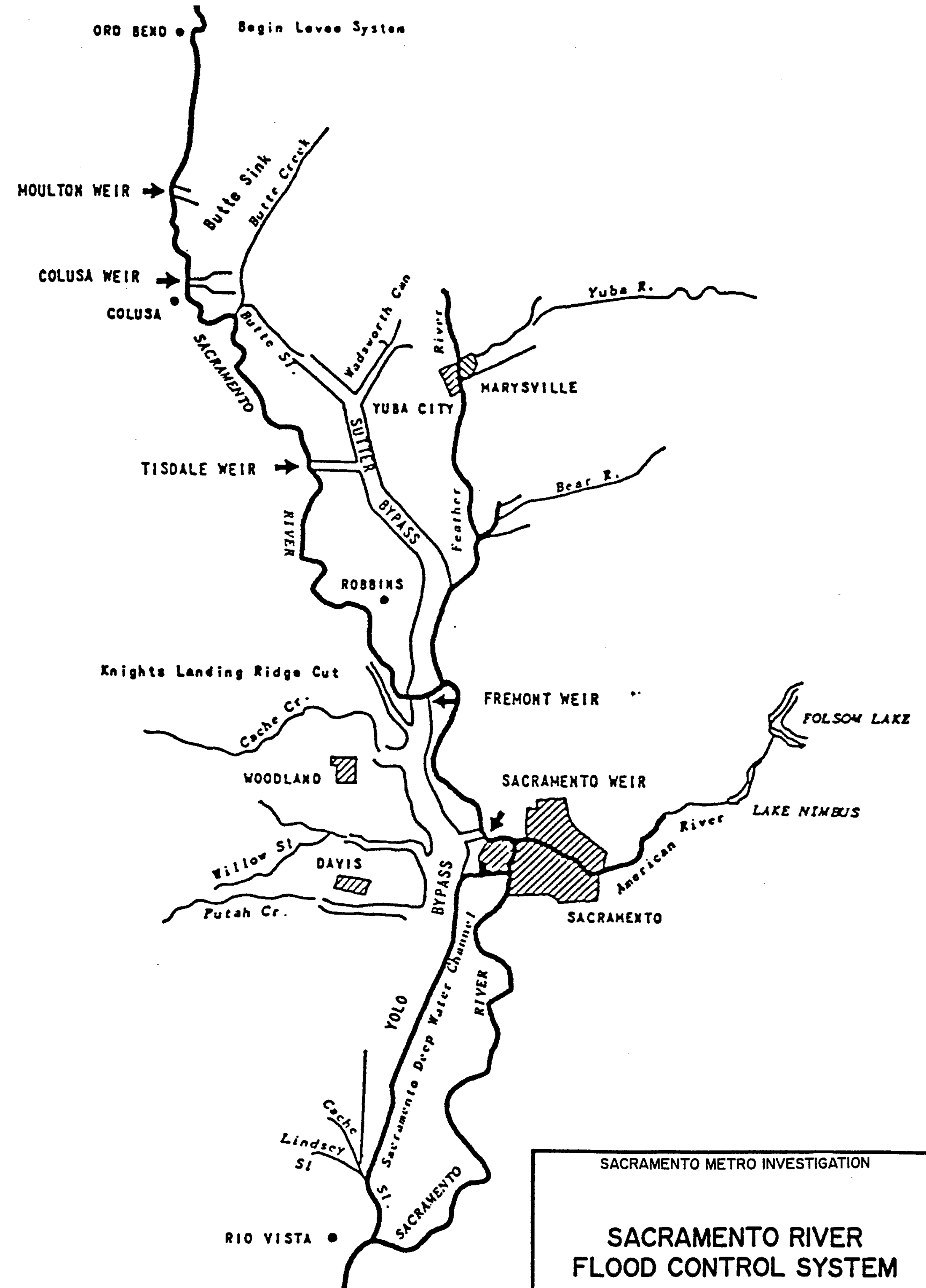
SACRAMENTO METRO INVESTIGATION

TOPOGRAPHIC AND NORMAL ANNUAL PRECIPITATION MAP ABOVE AUBURN DAM

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: R.F.C.
Drawn: C.A.P.
Date JUNE 1990

CHART 4



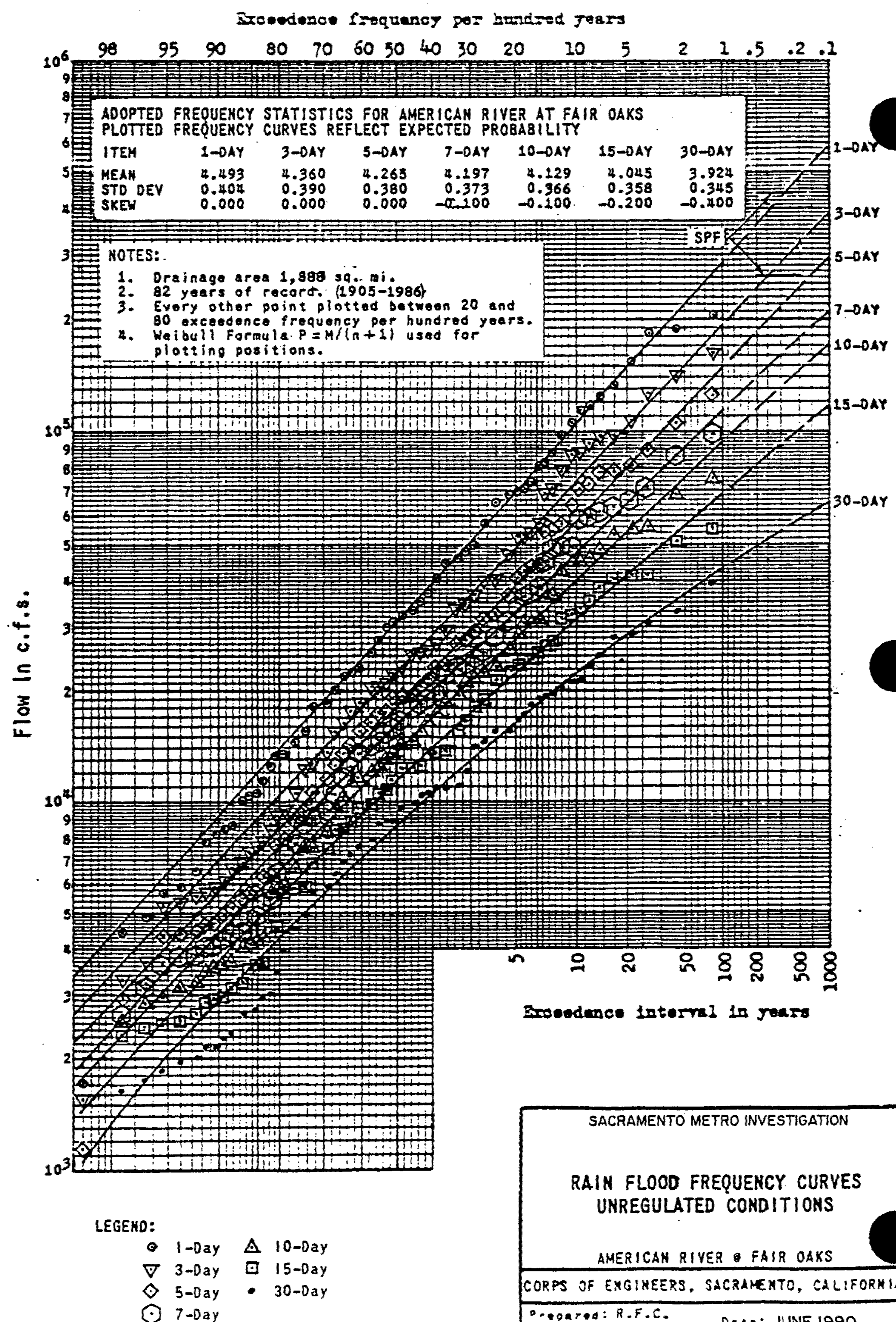
SACRAMENTO METRO INVESTIGATION

SACRAMENTO RIVER FLOOD CONTROL SYSTEM

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

CHART 5



SACRAMENTO METRO INVESTIGATION

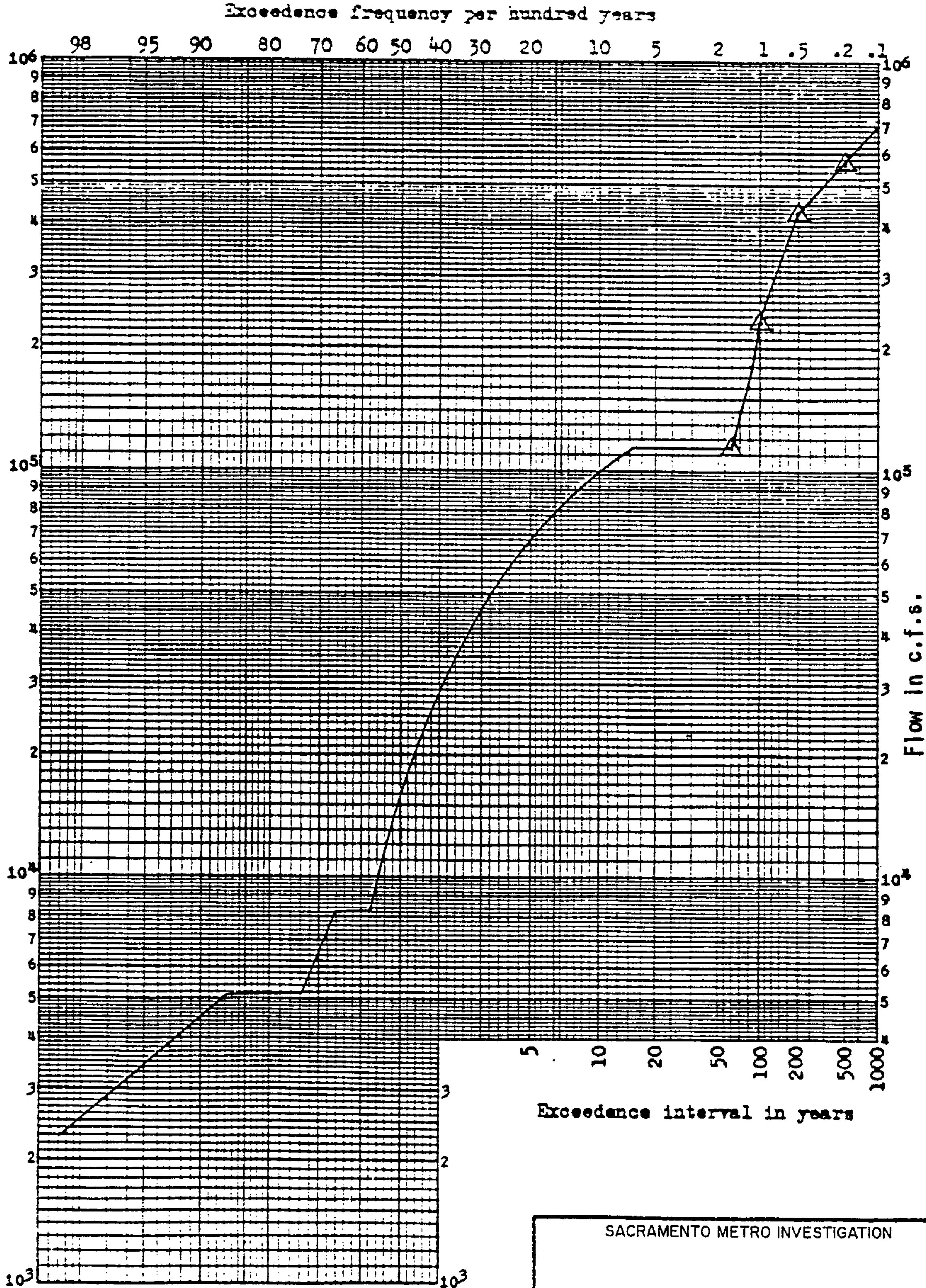
RAIN FLOOD FREQUENCY CURVES
UNREGULATED CONDITIONS

AMERICAN RIVER @ FAIR OAKS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: R.F.C.
Drawn: C.A.P.
Date: JUNE 1990

CHART 6



Notes:

1. The project curves, to the 50 year event, reflects 32 years of record (1955-1986).
2. The remaining portion of the curve reflect the results of hypothetical flood routings as represented by the plotted points.
3. The hypothetical routings used the present authorized flood operation of Folsom Dam.

SACRAMENTO METRO INVESTIGATION

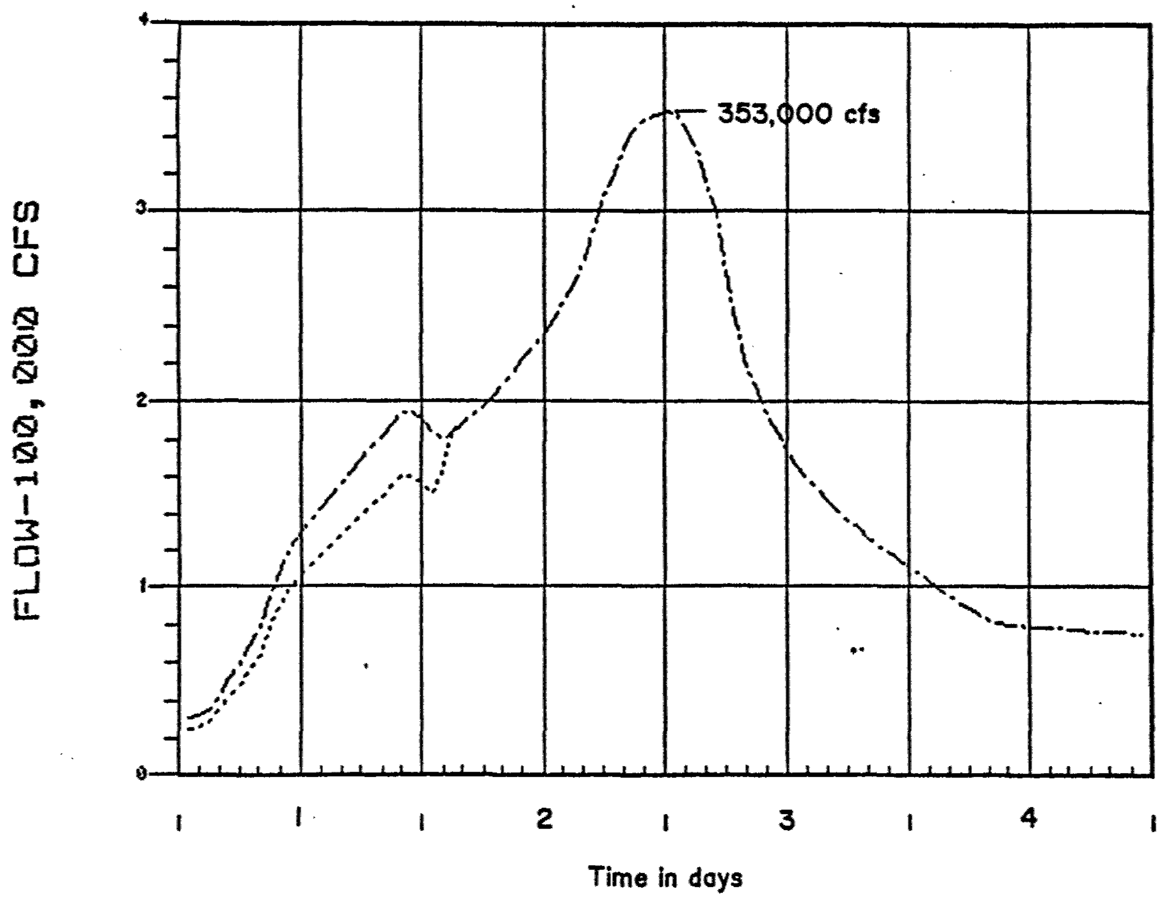
PEAK FLOW-FREQUENCY CURVE
EXISTING CONDITIONS

AMERICAN RIVER @ FAIR OAKS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: R.F.C.
Drawn: C.A.P.
Date: JUNE 1990

CHART 7



LEGEND:

—·— Unregulated flow

- - - - - Regulated inflow (Flow reduction due to storage in existing upstream reservoir).

SACRAMENTO METRO INVESTIGATION

100-YEAR FLOOD HYDROGRAPH

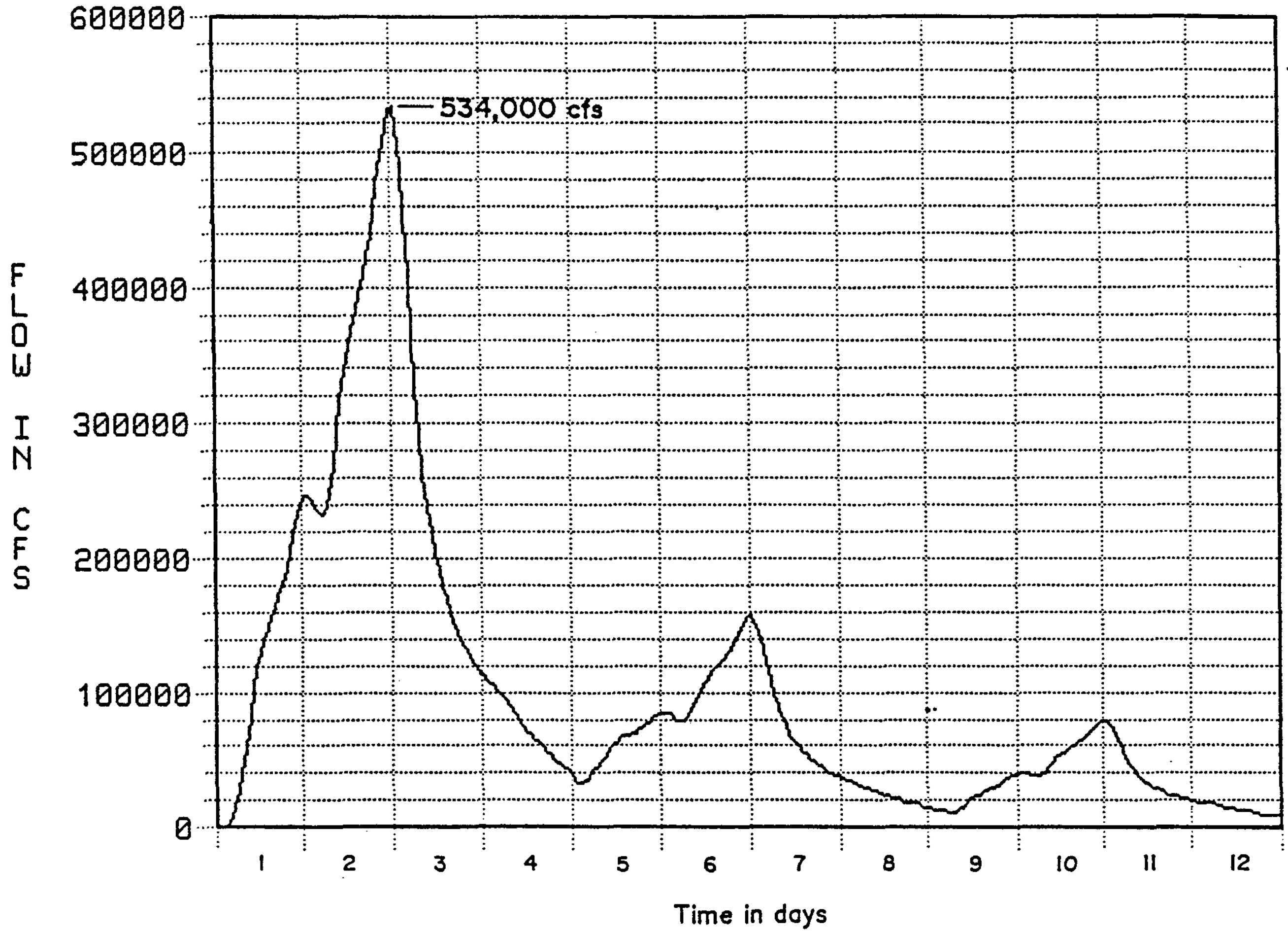
FOLSOM RESERVOIR INFLOW

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: R.F.C.
Drawn: C.A.P.

Date: JUNE 1990

CHART 8



SACRAMENTO METRO INVESTIGATION

STANDARD PROJECT FLOOD HYDROGRAPH

INFLOW INTO FOLSOM RESERVOIR

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.

Date: JUNE 1990

CHART 9

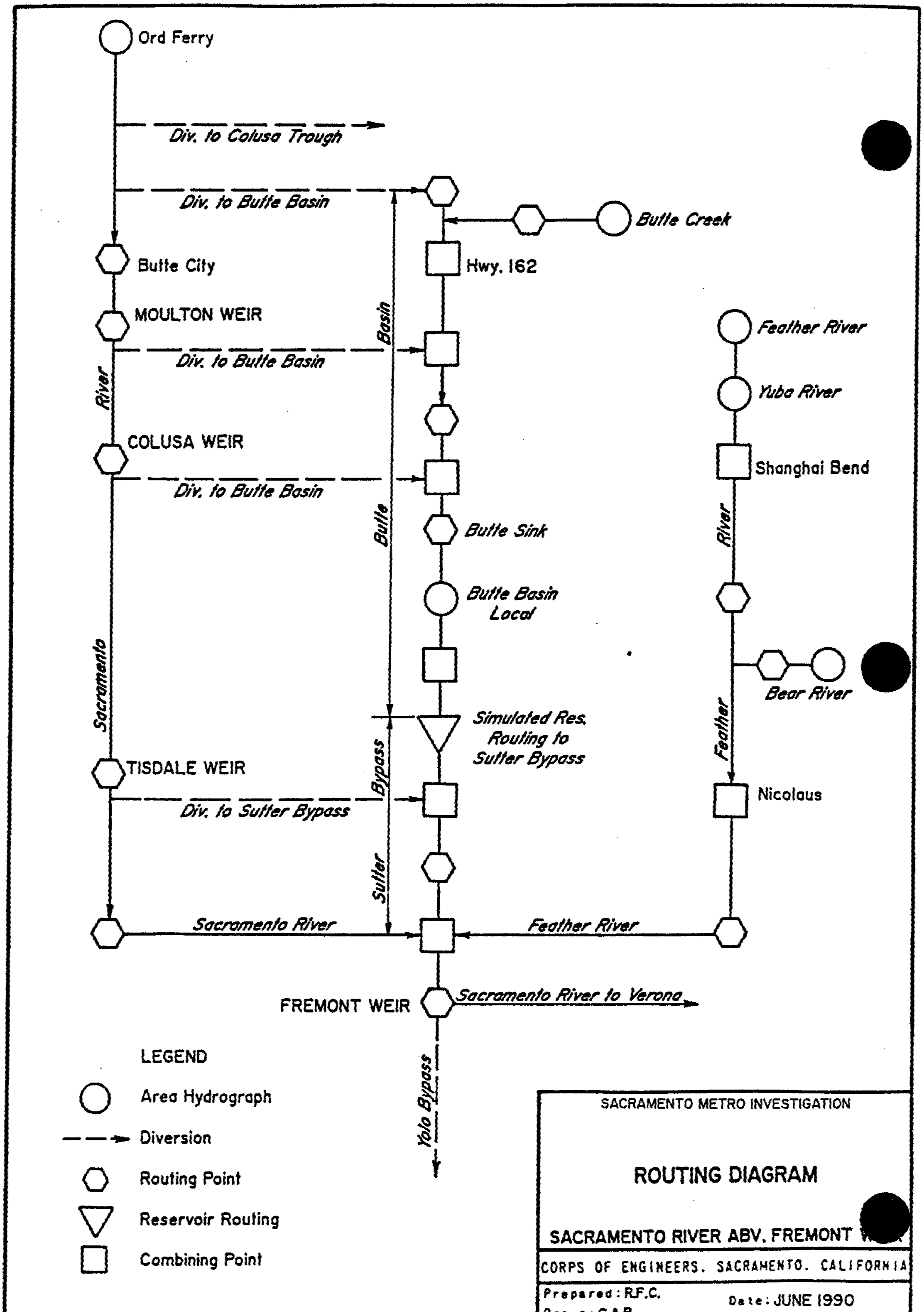
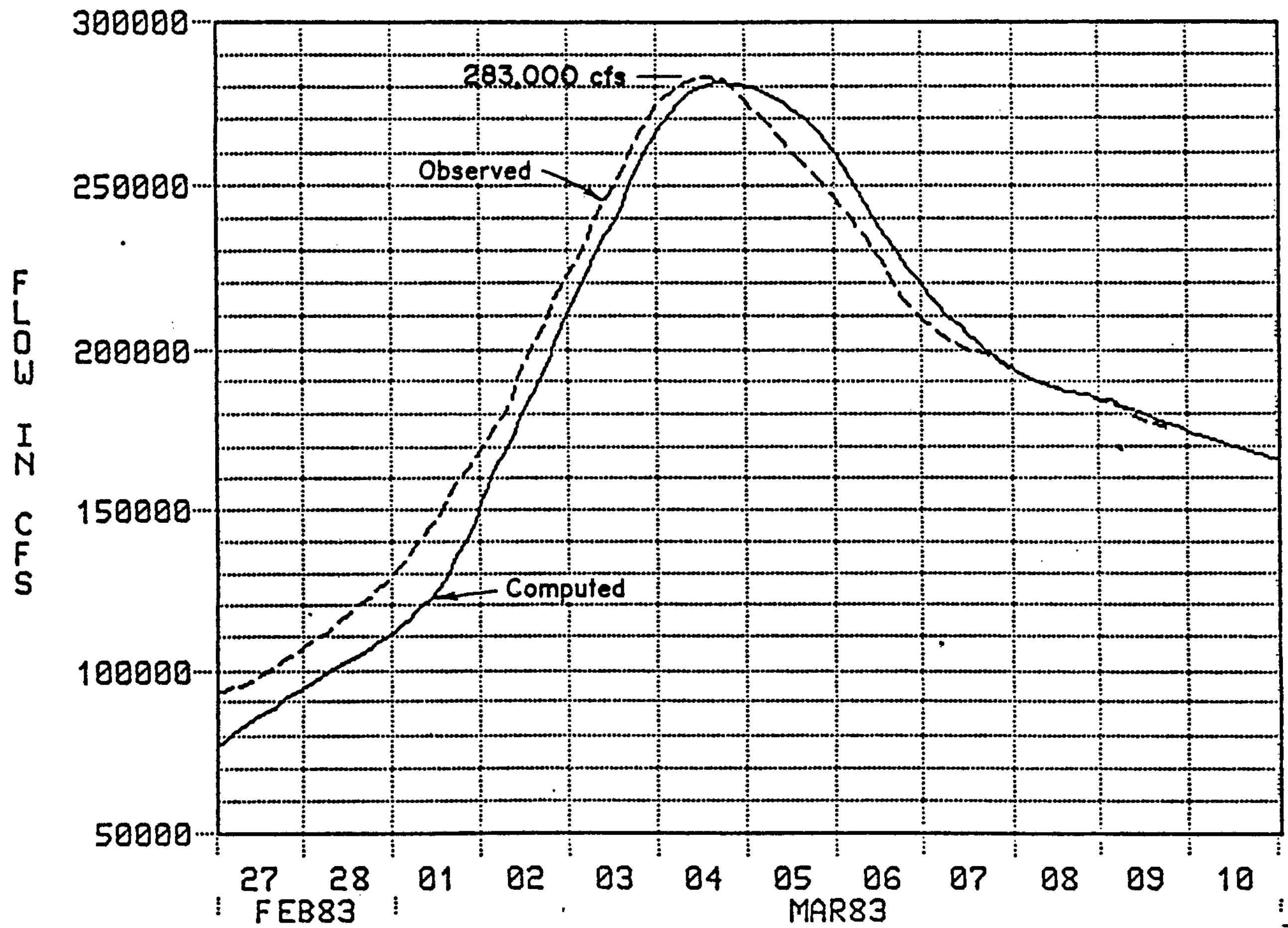

Ord Ferry
Div. to Colusa Trough
Div. to Butte Basin
Butte Creek
Butte City
Hwy. 162
MOULTON WEIR
Div. to Butte Basin
Feather River
River
Yuba River
COLUSA WEIR
Div. to Butte Basin
Shanghai Bend
Butte Sink
Butte Basin Local
Basin
Butte
River
Sacramento
Bear River
Feather
Simulated Res. Routing to Sutter Bypass
TISDALE WEIR
Bypass
Div. to Sutter Bypass
Nicolaus
Sutter
Sacramento River
Feather River
FREMONT WEIR
Sacramento River to Verona
Yolo Bypass
LEGEND
Area Hydrograph
Diversion
Routing Point
Reservoir Routing
Combining Point
SACRAMENTO METRO INVESTIGATION
ROUTING DIAGRAM
SACRAMENTO RIVER ABV. FREMONT
CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA
Prepared: R.F.C.
Drawn: C.A.P.
Date: JUNE 1990

CHART 10



SACRAMENTO METRO INVESTIGATION

1983 COMPUTED & OBSERVED HYDROGRAPHS

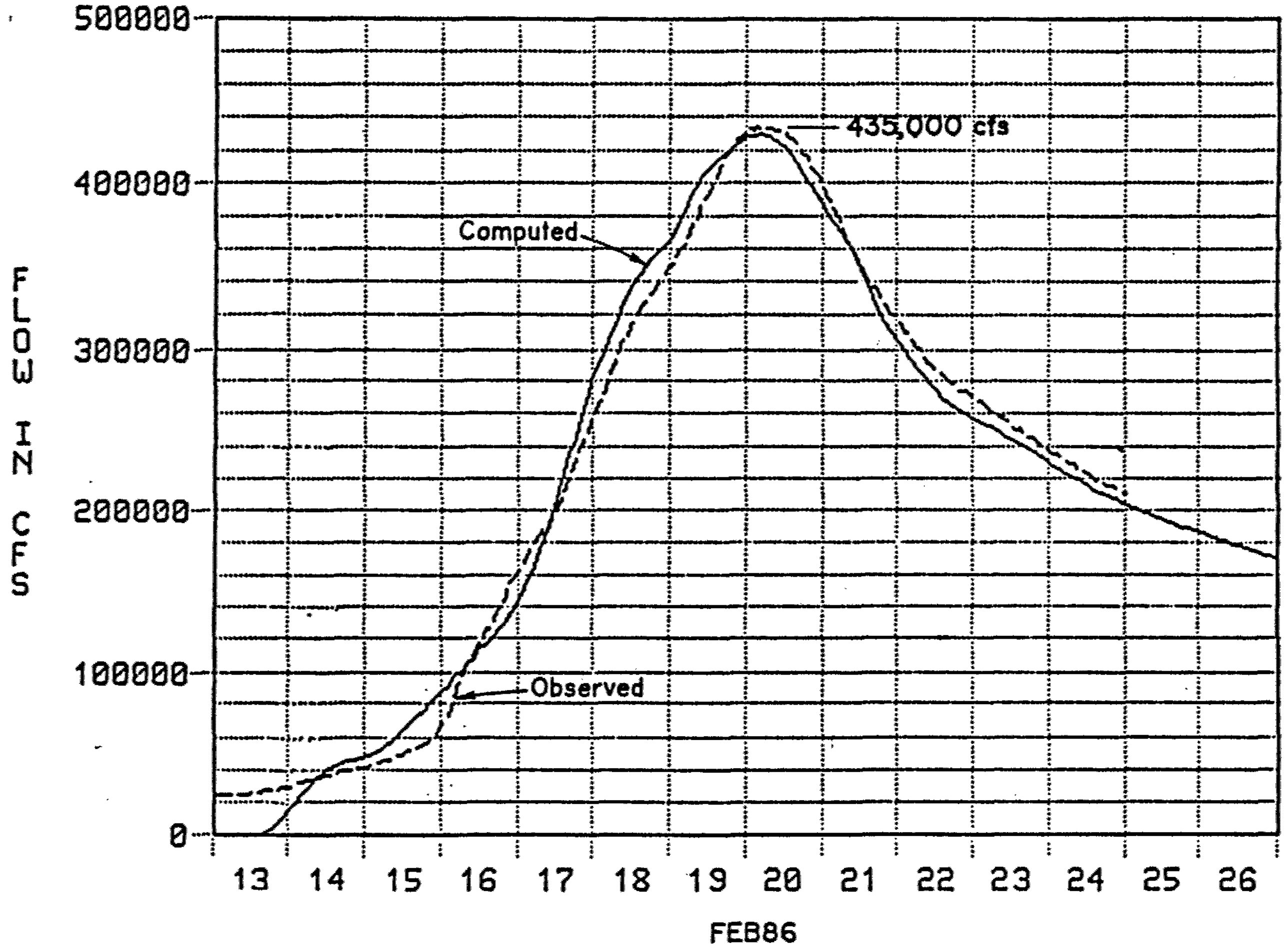
SACRAMENTO AND FEATHER RIVER CONFLUENCE

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: R.F.C.
Drawn: C.A.P.

Date: JUNE 1990

CHART 11



SACRAMENTO METRO INVESTIGATION

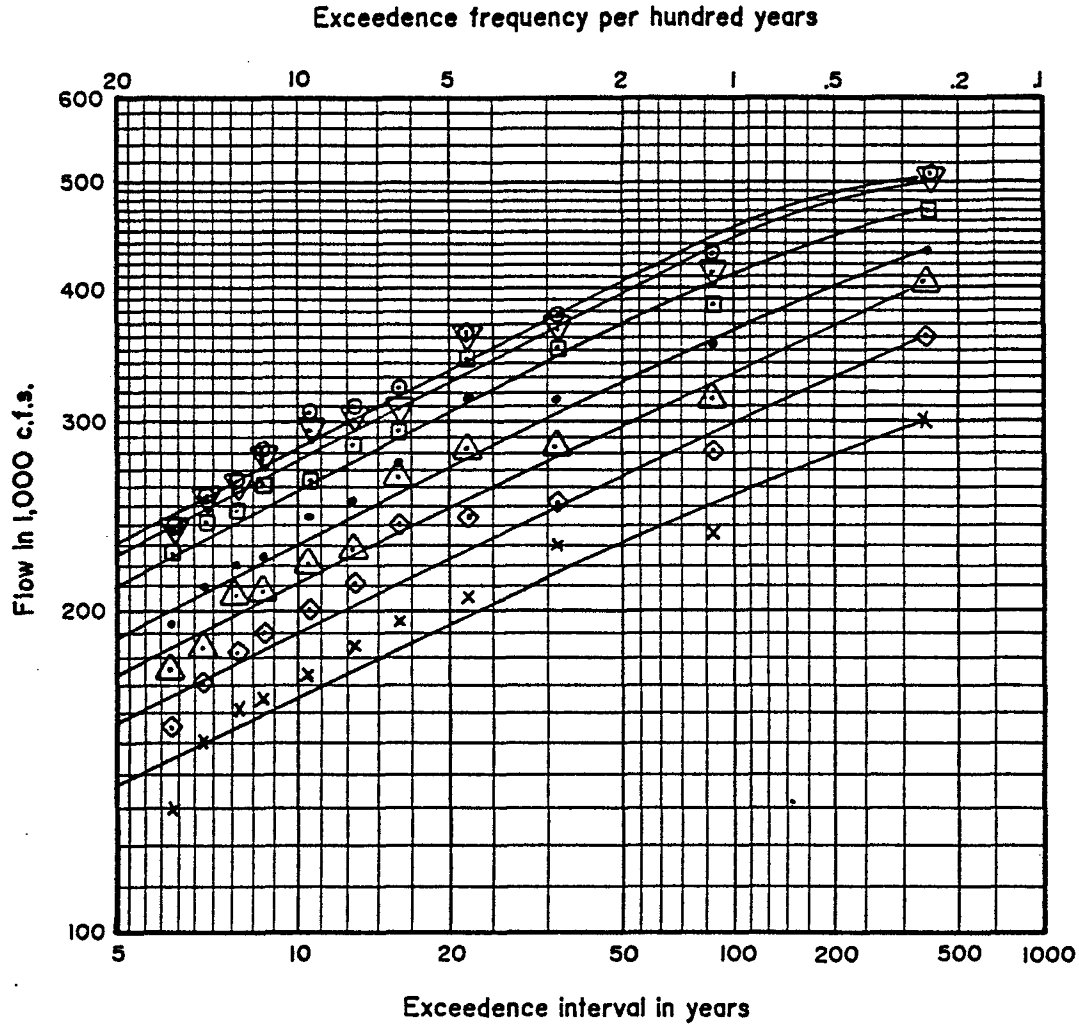
1986 COMPUTED & OBSERVED HYDROGRAPHS

SACRAMENTO AND FEATHER RIVER CONFLUENCE

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: R.F.C.
Drawn: C.A.P.
Date: JUNE 1990

CHART 12



PEAK AND VOLUME STATISTICS FOR
PRESENT CONDITION FREQUENCY CURVES

Log of	Peak	1-Day	3-Day	5-Day	7-Day	10-Day	15-Day
Mean	2.200	2.193	2.165	2.115	2.080	2.040	1.980
Std. Dev.	0.198	0.196	0.196	0.193	0.191	0.188	.0185
Skew	0	0	0	0	0	0	0

LEGEND

- ⊙ Peak
- ▽ 1-Day
- ⊡ 3-Day
- • 5-Day
- △ 7-Day
- ◇ 10-Day
- × 15-Day

1. Plotted points between the .6 and .01 event are regulated historical flows.
2. Plotted points beyond the .01 event are regulated hypothetical floods.

SACRAMENTO METRO INVESTIGATION

FLOOD FLOW FREQUENCY CURVES

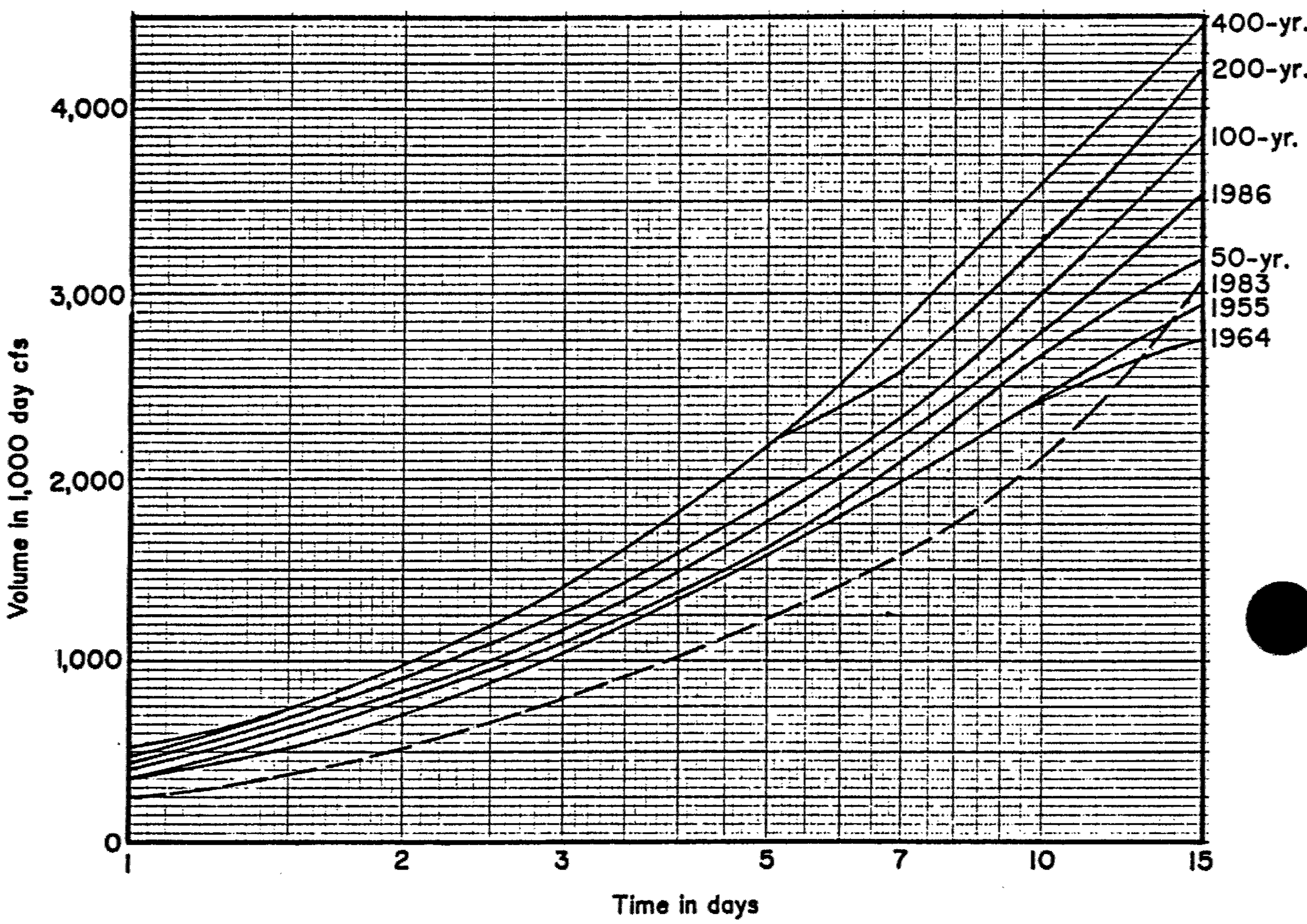
SACRAMENTO AND FEATHER RIVER CONFLUENCE

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: R.F.C.
Drawn: C.A.P.

Date: JUNE 1990

CHART 13



NOTE:
The 2 and 4 hundred year curves reflect upstream levee failure.

SACRAMENTO METRO INVESTIGATION

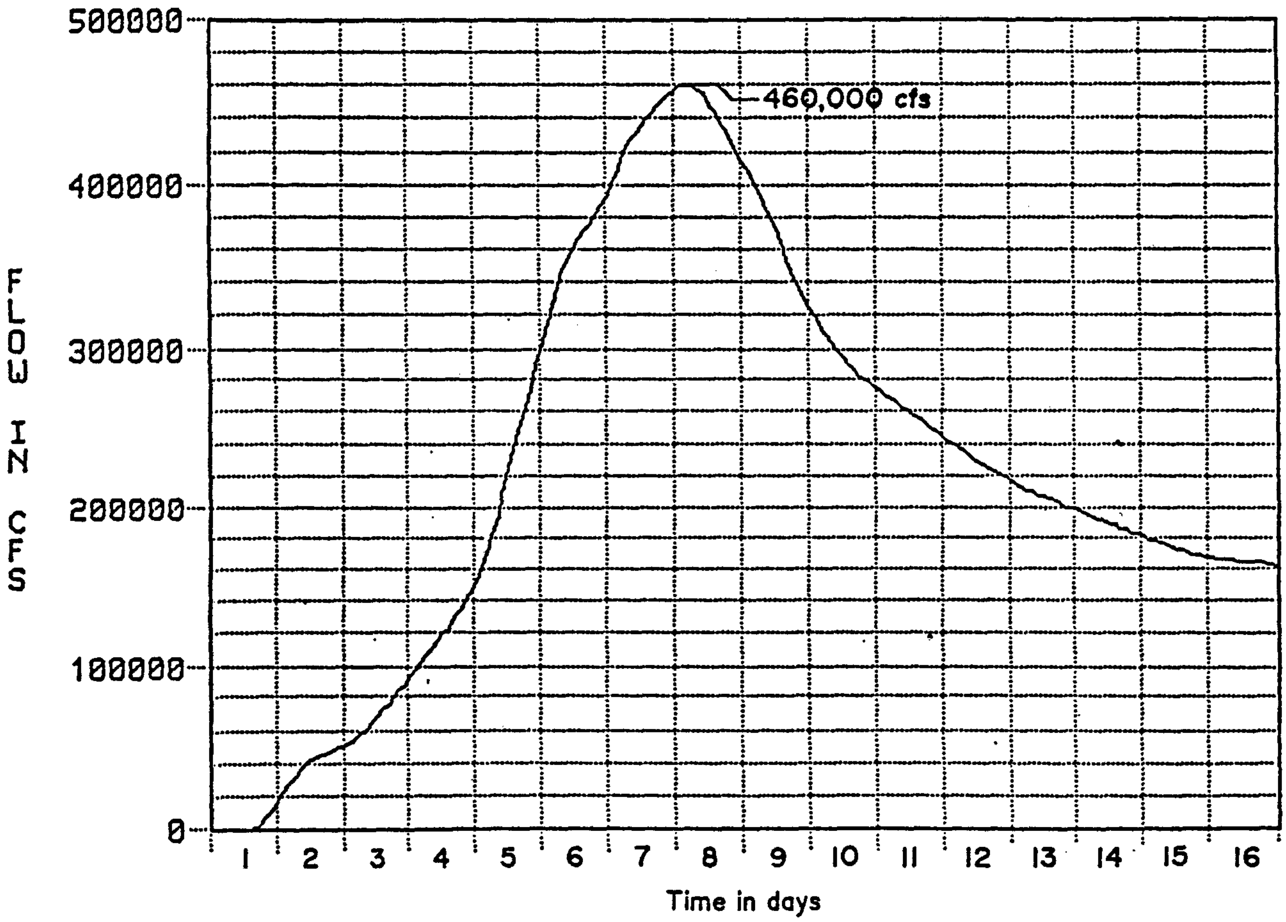
FLOOD VOLUME
MASS CURVES

SACRAMENTO AND FEATHER RIVER CONFLUENCE

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: R.F.C.
Drawn: C.A.P.
Date: JUNE 1990

CHART 14



SACRAMENTO METRO INVESTIGATION

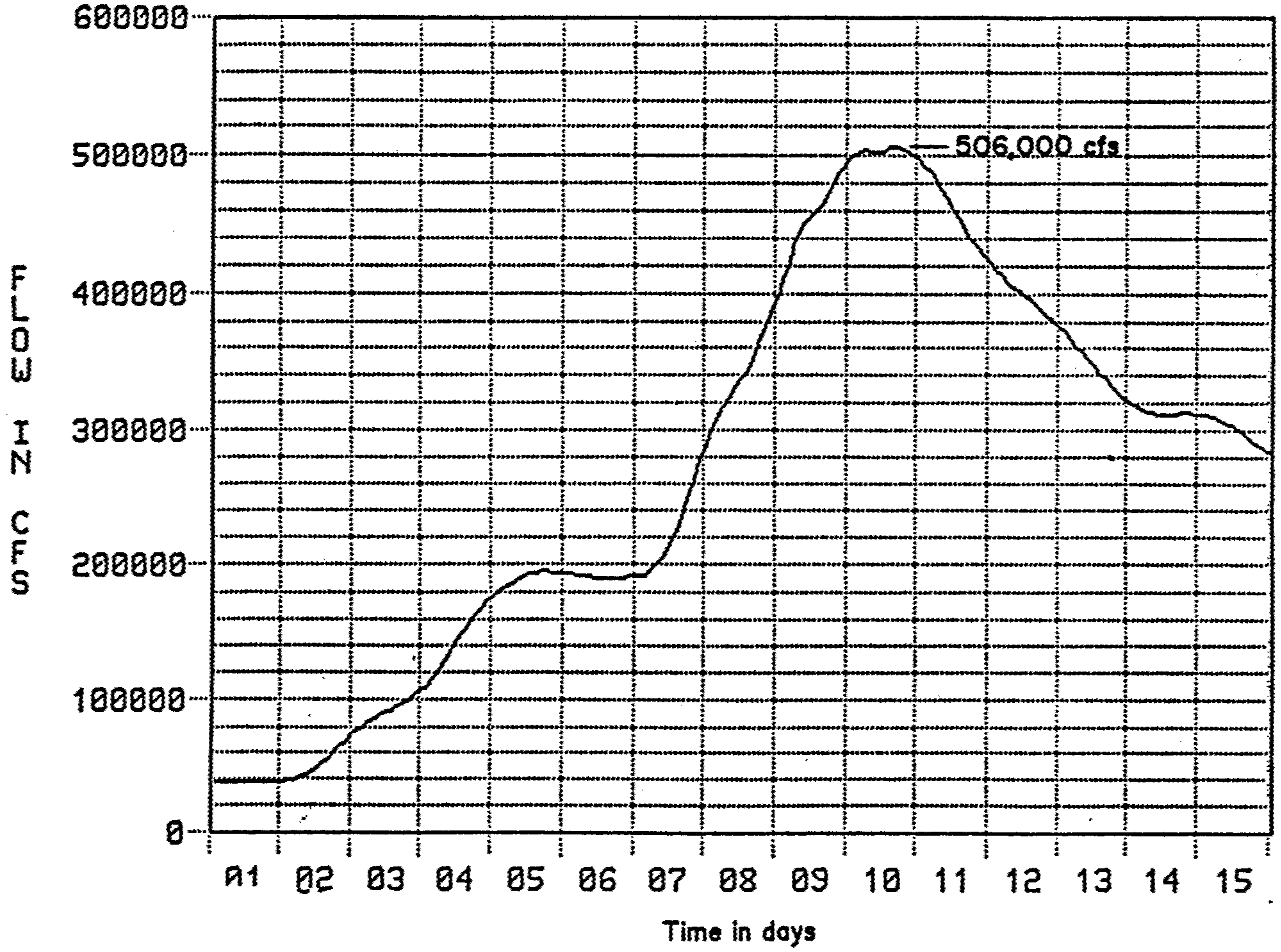
100-YEAR FLOOD HYDROGRAPH

SACRAMENTO AND FEATHER RIVER CONFLUENCE

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: R.F.C. Date: JUNE 1990
Drawn: C.A.P.

CHART 15



SACRAMENTO METRO INVESTIGATION

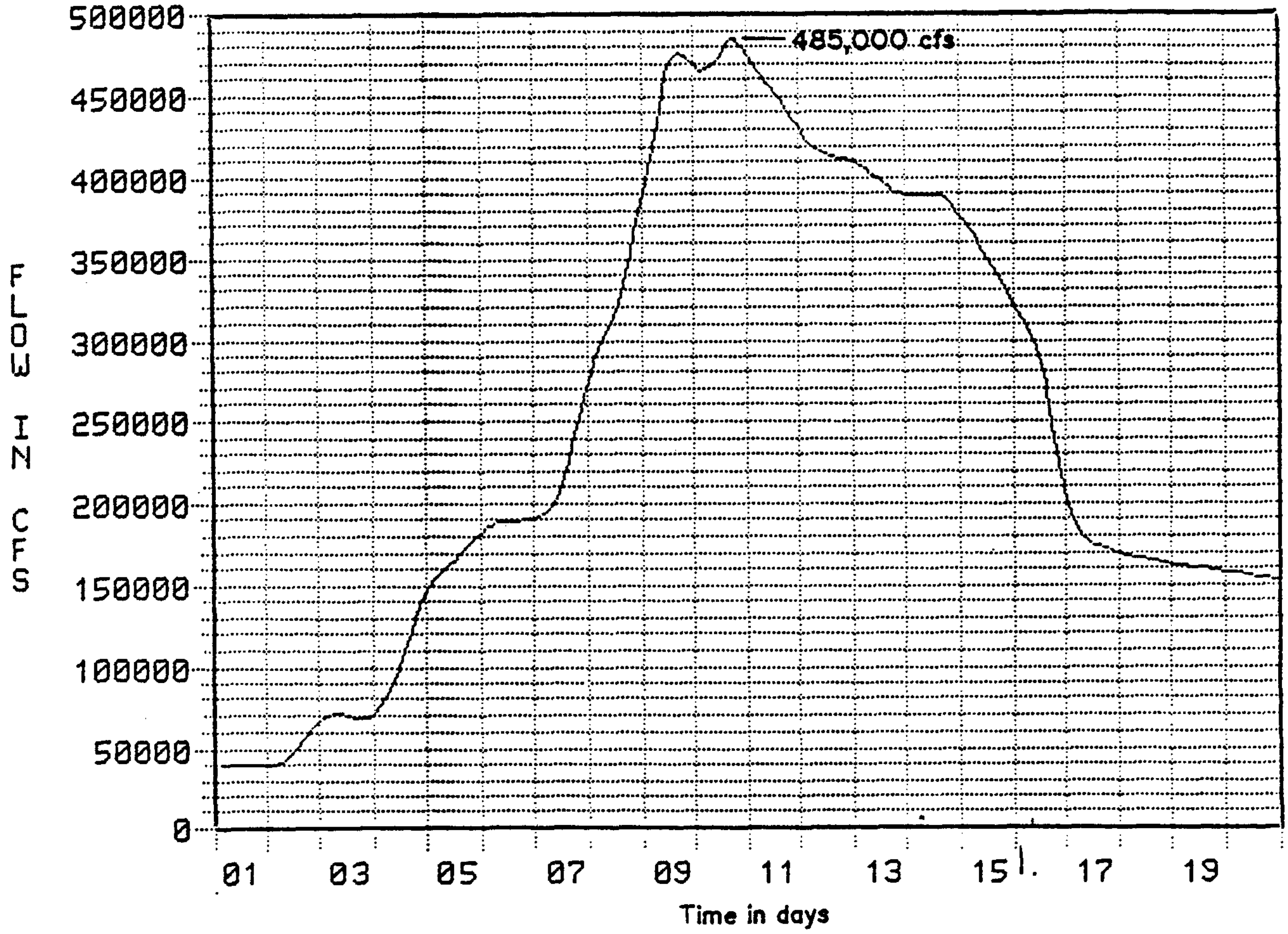
400-YEAR FLOOD HYDROGRAPH

SACRAMENTO AND FEATHER RIVER
CONFLUENCE

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: R.F.C.
Drawn: C.A.P.
Date: JUNE 1990

CHART 16



SACRAMENTO METRO INVESTIGATION

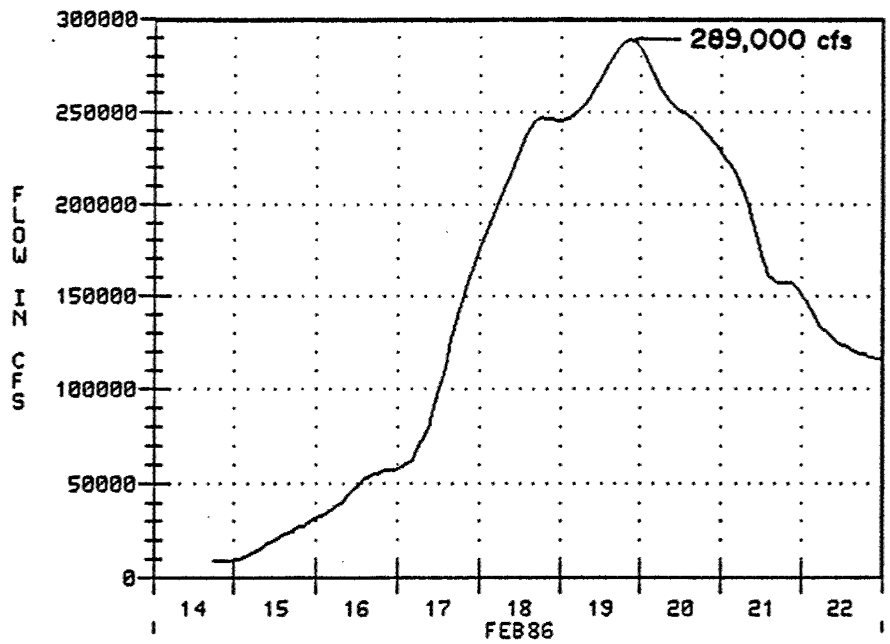
200-YEAR FLOOD HYDROGRAPH

SACRAMENTO AND FEATHER RIVER CONFLUENCE

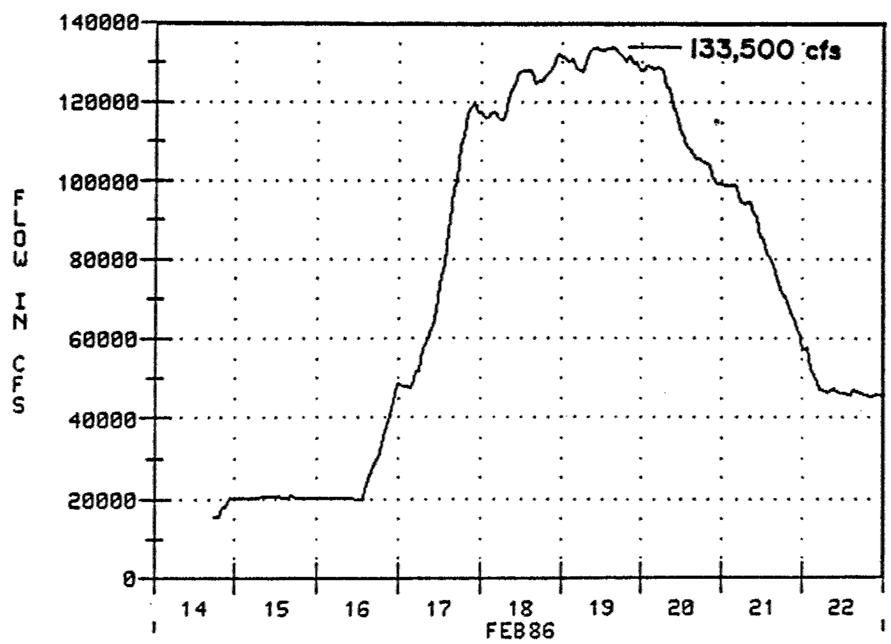
CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: R.F.C.
Drawn: C.A.P.
Date: JUNE 1990

CHART 17



FEATHER RIVER D/S BEAR RIVER



AMERICAN RIVER @ FAIR OAKS

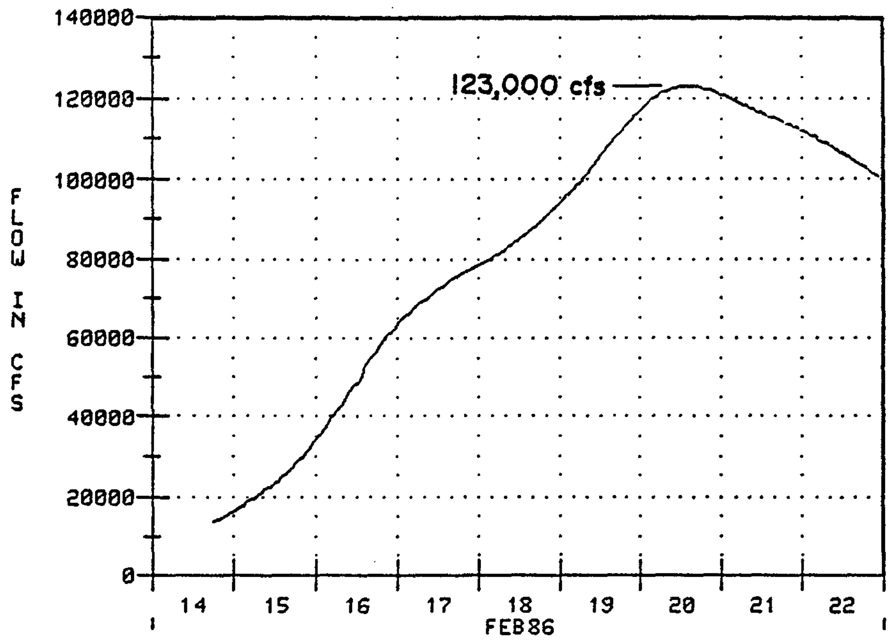
SACRAMENTO METRO INVESTIGATION

1986 OBSERVED HYDROGRAPHS

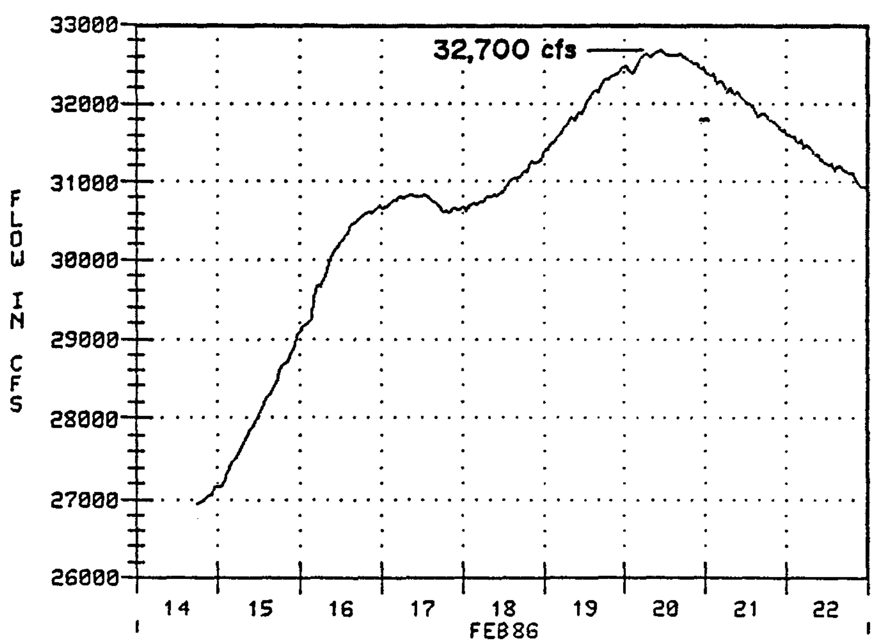
CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.
Date: JUNE 1990

SHEET 1 OF 2 CHART 18



SUTTER BYPASS BELOW TISDALE WEIR



SACRAMENTO RIVER @ WILKINS SL.

SACRAMENTO METRO INVESTIGATION

1986 OBSERVED HYDROGRAPHS

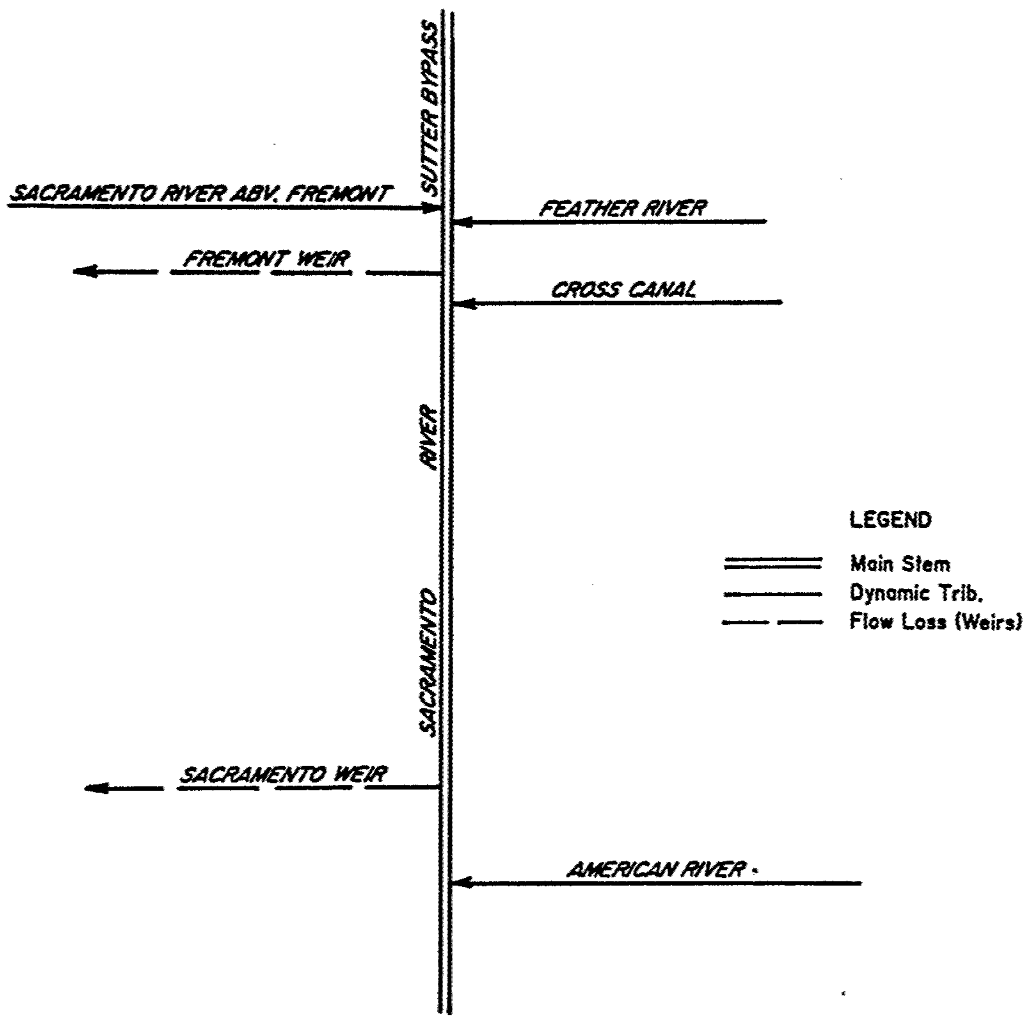
CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.

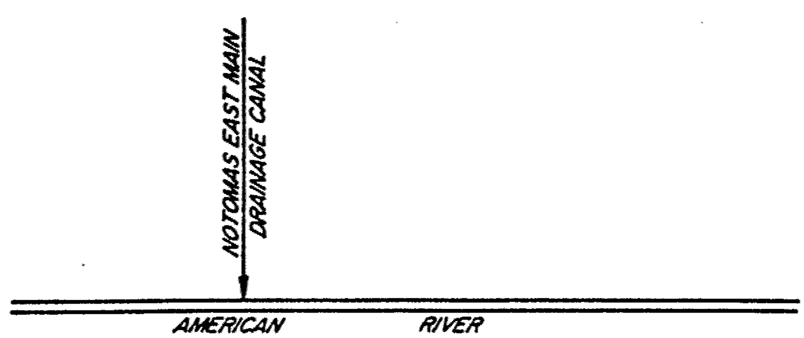
Date: JUNE 1990

SHEET 2 OF 2 CHART 18

SACRAMENTO RIVER MODEL



AMERICAN RIVER MODEL



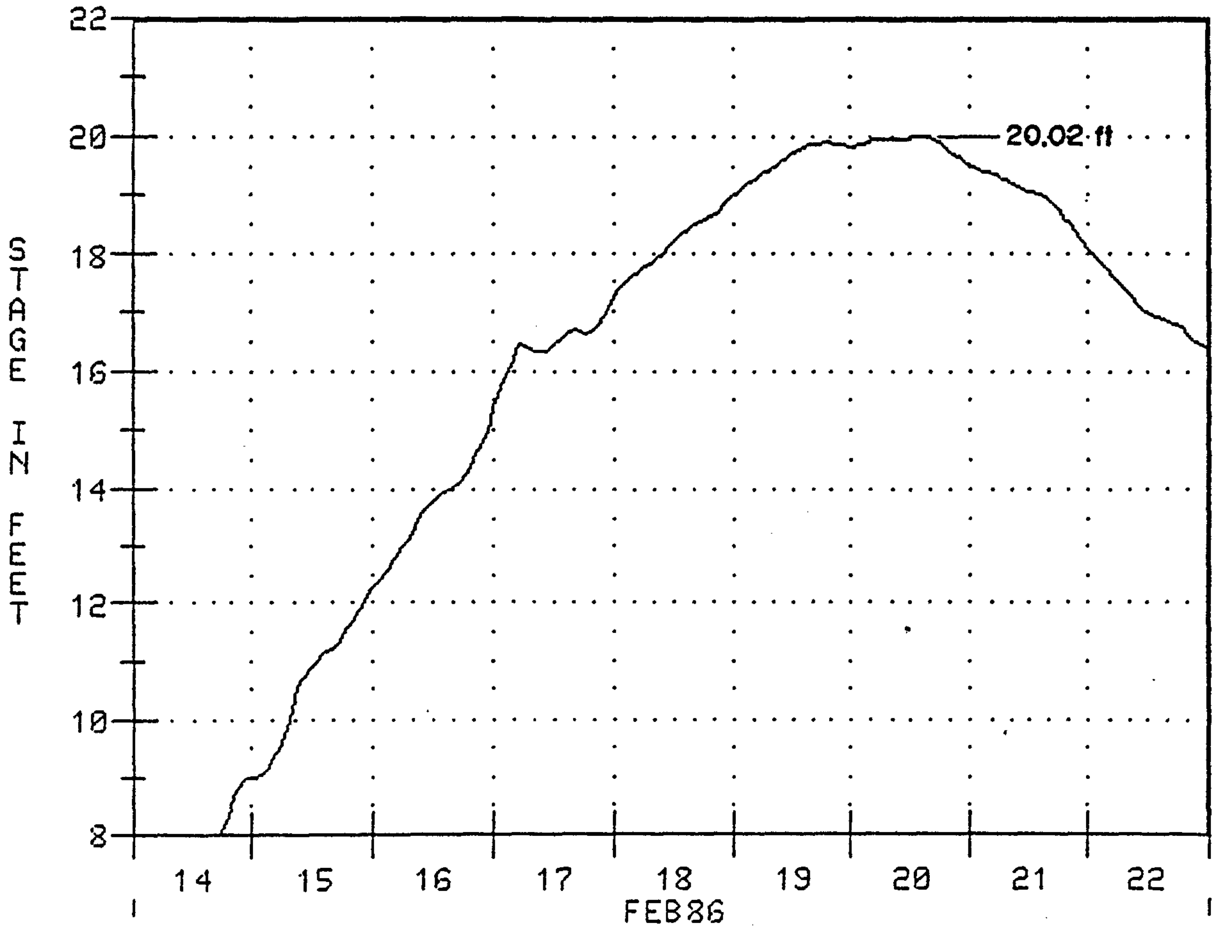
SACRAMENTO METRO INVESTIGATION

SCHEMATIC DIAGRAM

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.
Date: JUNE 1990

CHART 19



SACRAMENTO METRO INVESTIGATION

1986 OBSERVED HYDROGRAPH

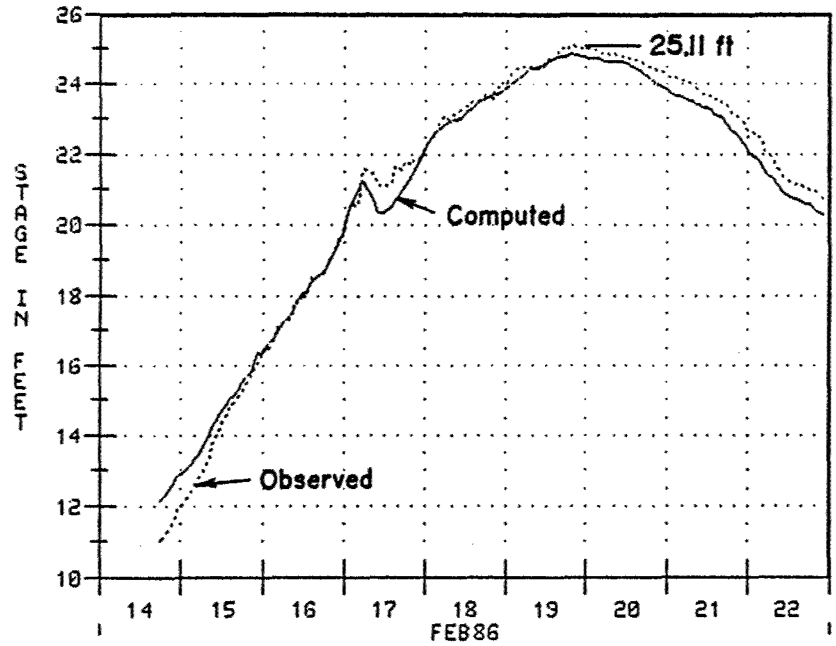
SACRAMENTO RIVER @ SNODGRASS SL.

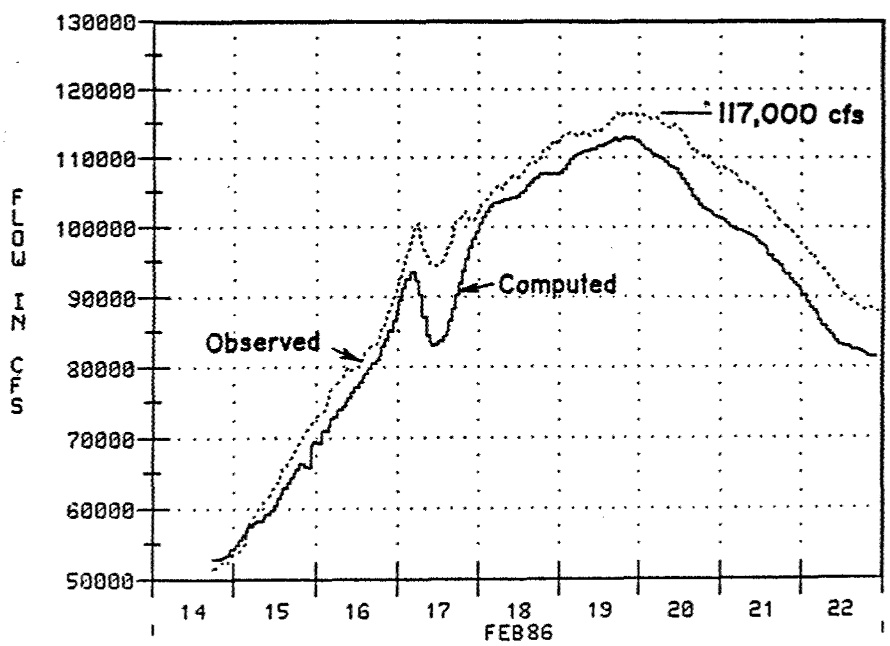
CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.

Date: JUNE 1990

SHEET 1 OF 11 CHART 20





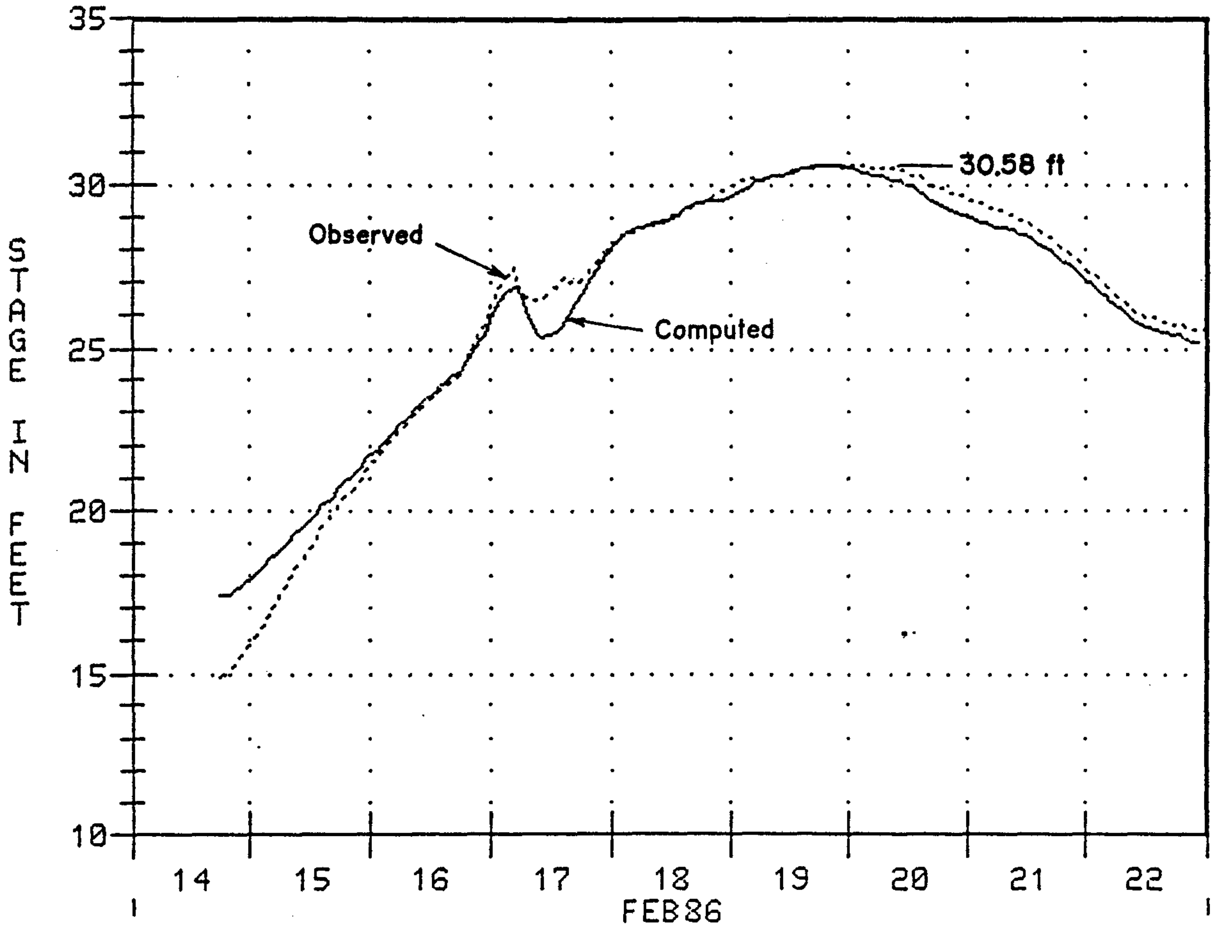
SACRAMENTO METRO INVESTIGATION

1986 COMPUTED & OBSERVED HYDROGRAPHS

SACRAMENTO RIVER @ FREEPORT

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H. Drawn: C.A.P.	Date: JUNE 1990



SACRAMENTO METRO INVESTIGATION

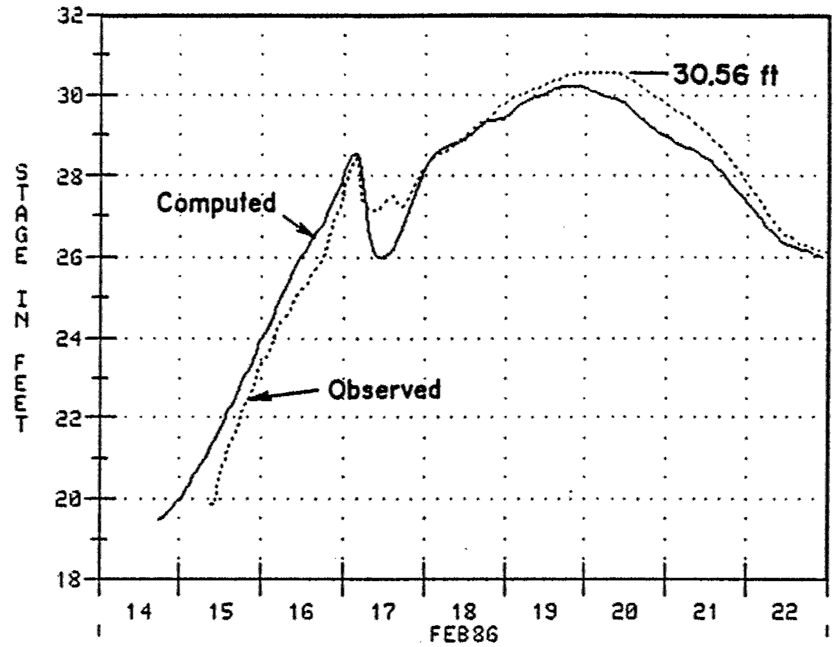
1986 COMPUTED & OBSERVED HYDROGRAPHS

SACRAMENTO RIVER @ "I" STREET

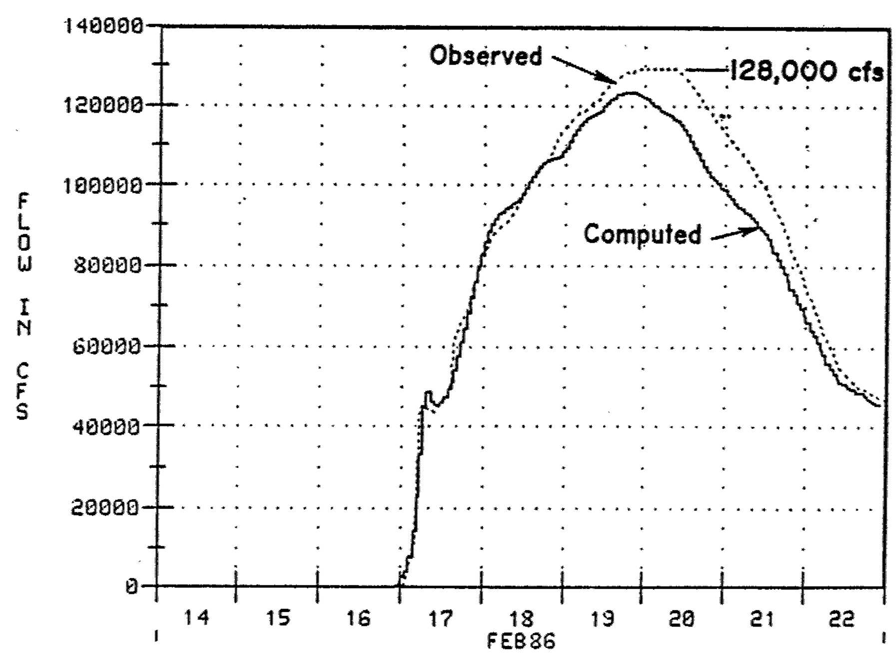
CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H. Date: JUNE 1990
Drawn: C.A.P.

SHEET 3 OF 11 CHART 20



SACRAMENTO R. @ U/S END OF SAC WEIR



SACRAMENTO WEIR SPILL TO YOLO BYPASS

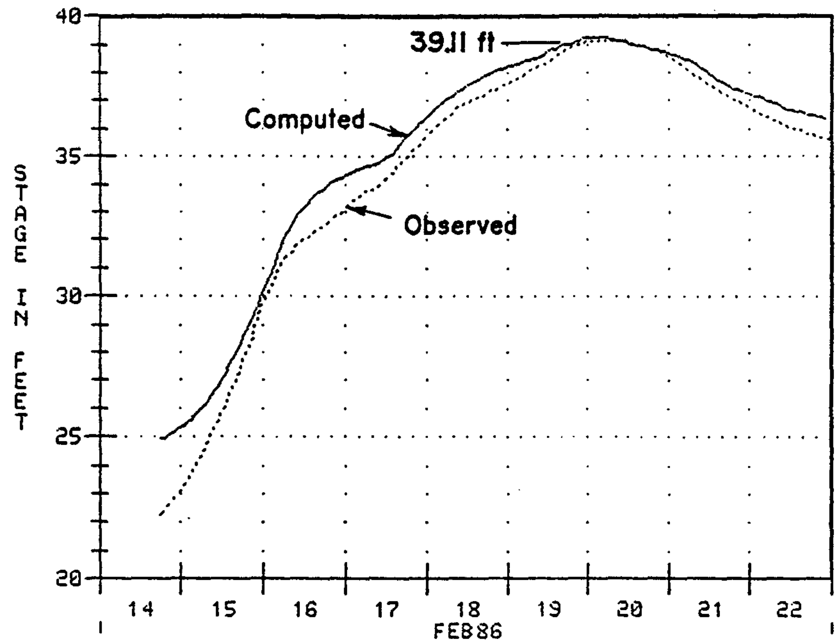
SACRAMENTO METRO INVESTIGATION

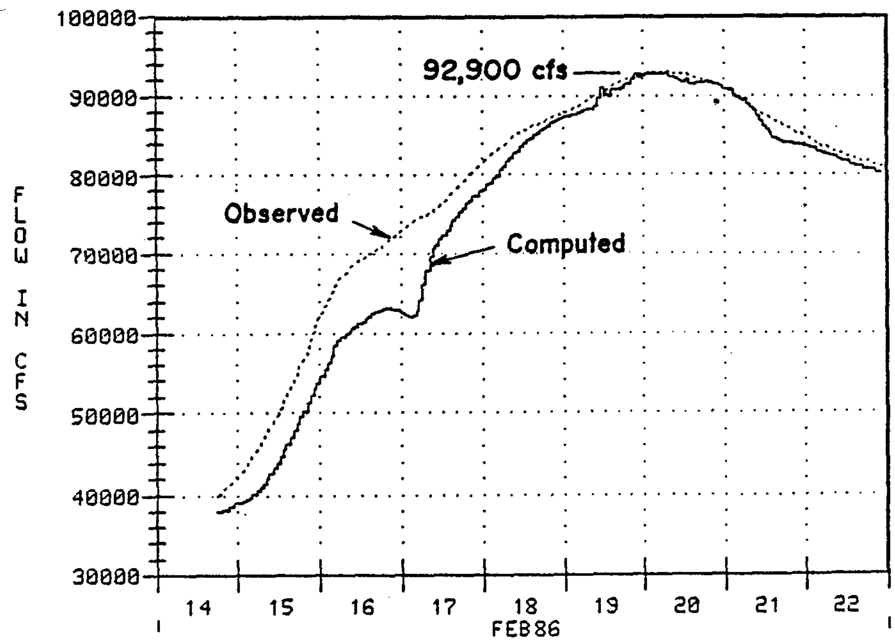
1986 COMPUTED & OBSERVED HYDROGRAPHS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.

Date: JUNE 1990





SACRAMENTO METRO INVESTIGATION

1986 COMPUTED & OBSERVED HYDROGRAPHS

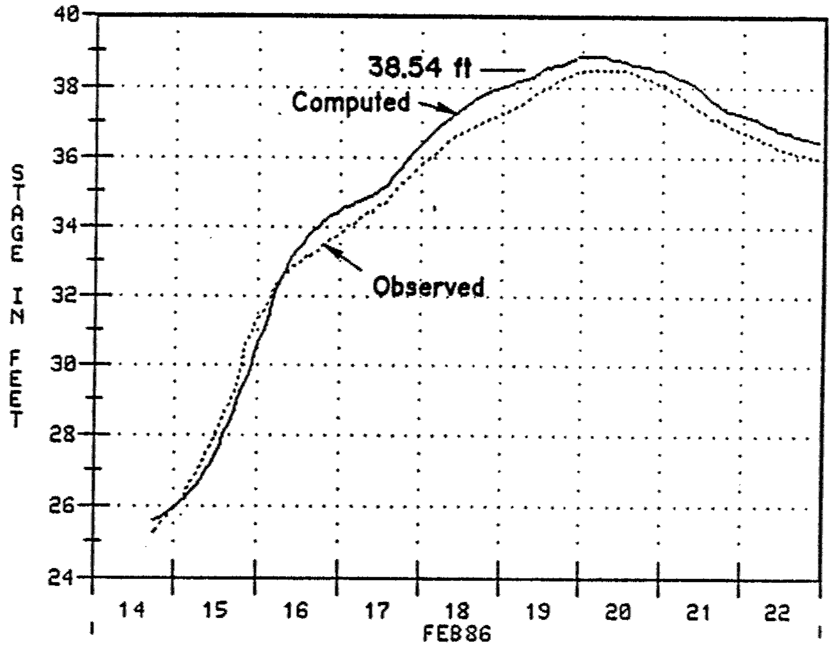
SACRAMENTO RIVER @ VERONA

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

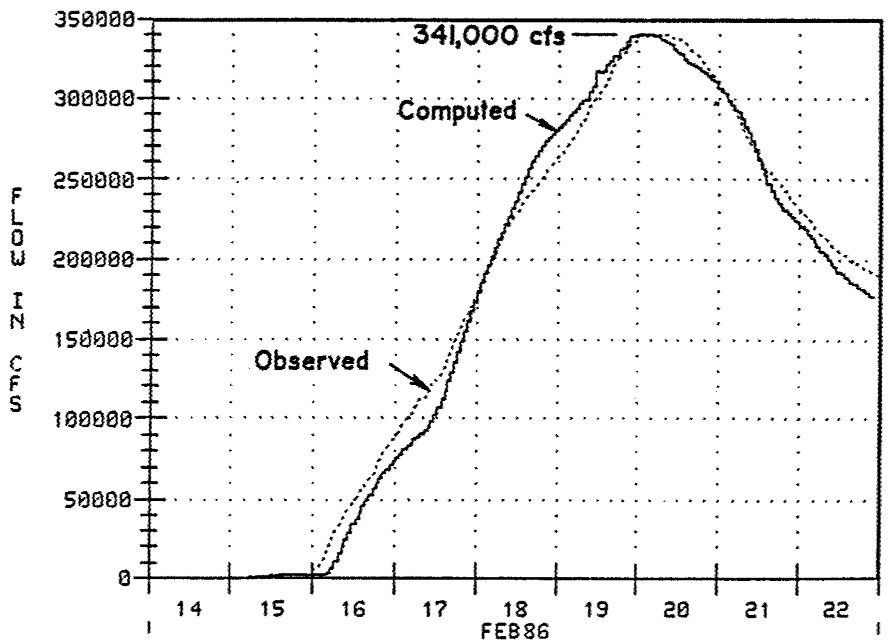
Prepared: J.H.
Drawn: C.A.P.

Date: JUNE 1990

SHEET 5 OF 11 CHART 20



SACRAMENTO RIVER @ FREMONT WEIR WEST END



FREMONT SPILL TO YOLO BYPASS

SACRAMENTO METRO INVESTIGATION

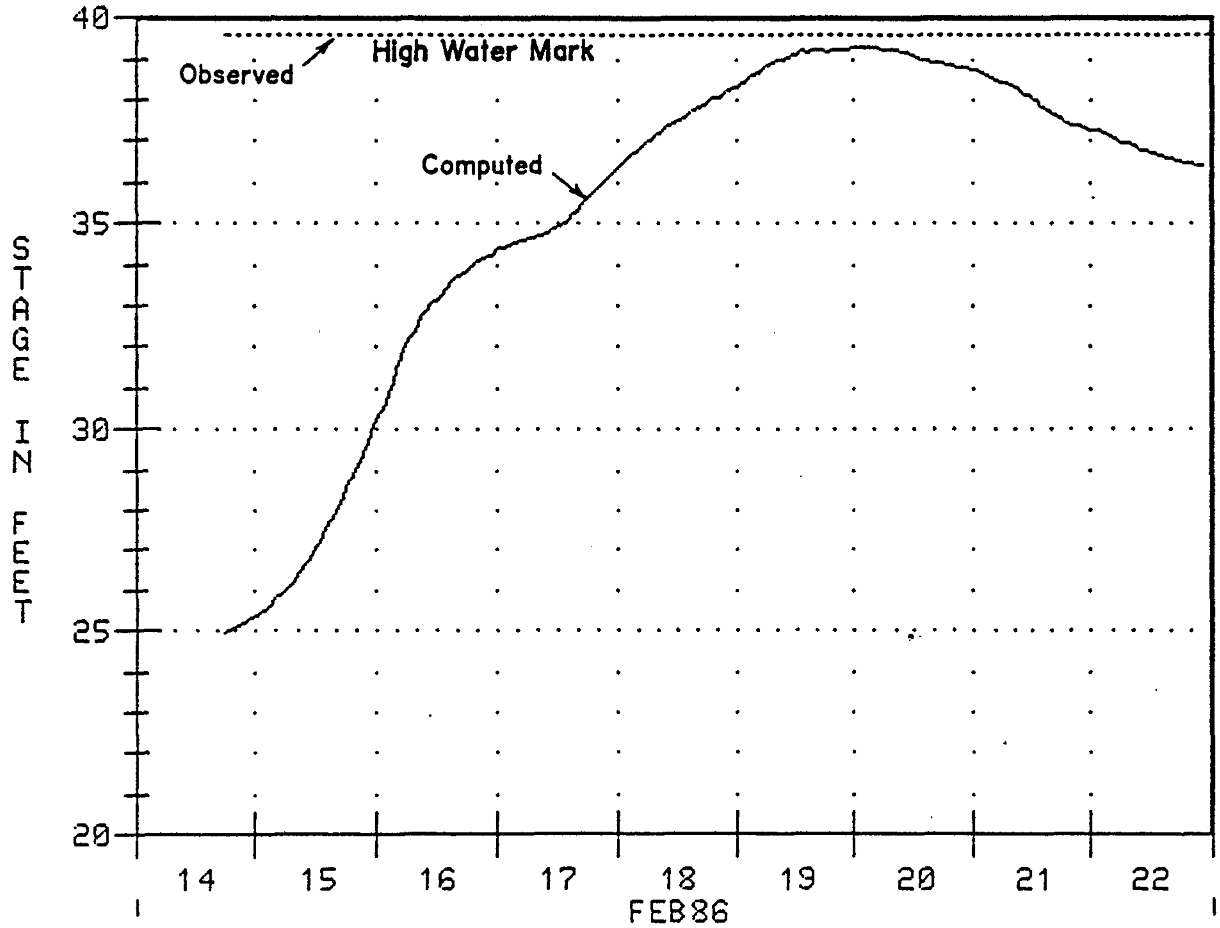
1986 COMPUTED & OBSERVED HYDROGRAPHS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.

Date: JUNE 1990

SHEET 6 OF 11 CHART 20



SACRAMENTO METRO INVESTIGATION

1986 COMPUTED & OBSERVED HYDROGRAPHS

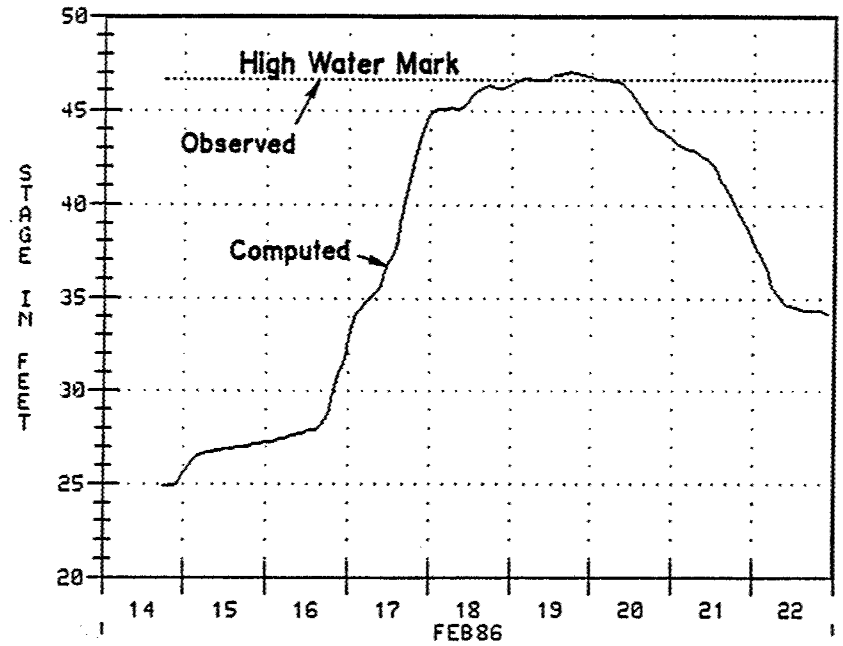
CROSS CANAL @ HY. 99

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

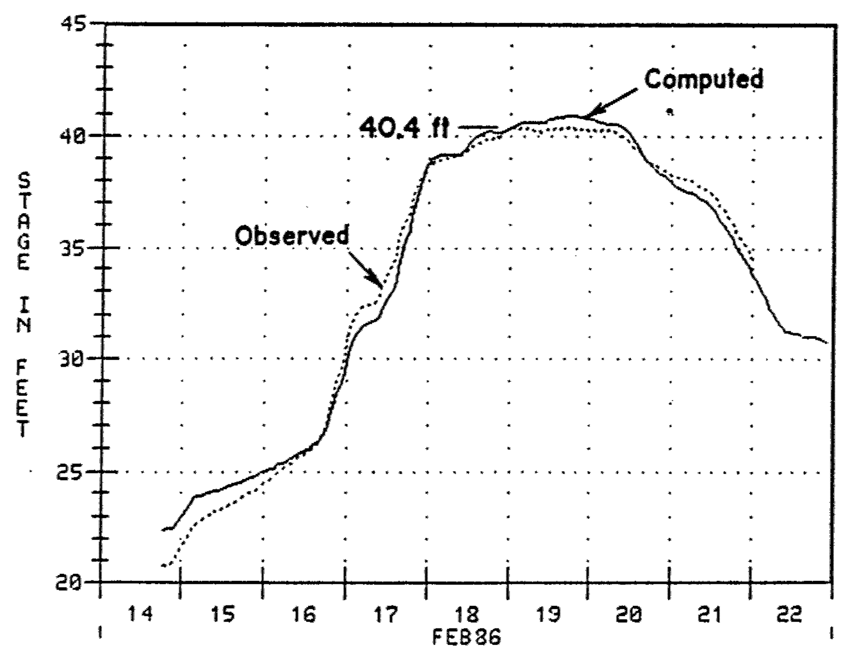
Prepared: J.H.
Drawn: C.A.P.

Date: JUNE 1990

SHEET 7 OF 11 CHART 20



@ WATT AVE.



@ H STREET

SACRAMENTO METRO INVESTIGATION

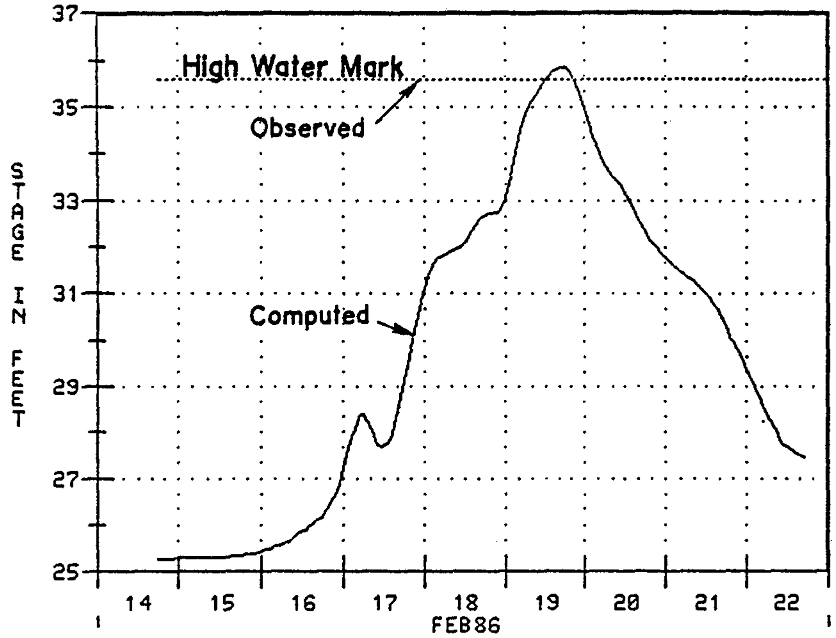
1986 COMPUTED & OBSERVED HYDROGRAPHS

AMERICAN RIVER

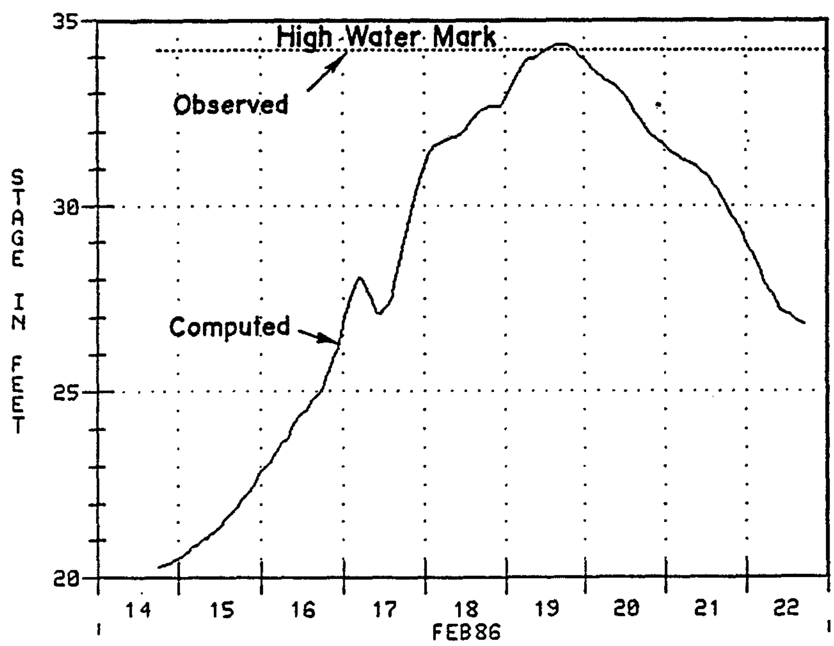
CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.
Date: JUNE 1990

SHEET 8 OF 11 CHART 20



@ MAIN AVE.



@ EL CAMINO

SACRAMENTO METRO INVESTIGATION

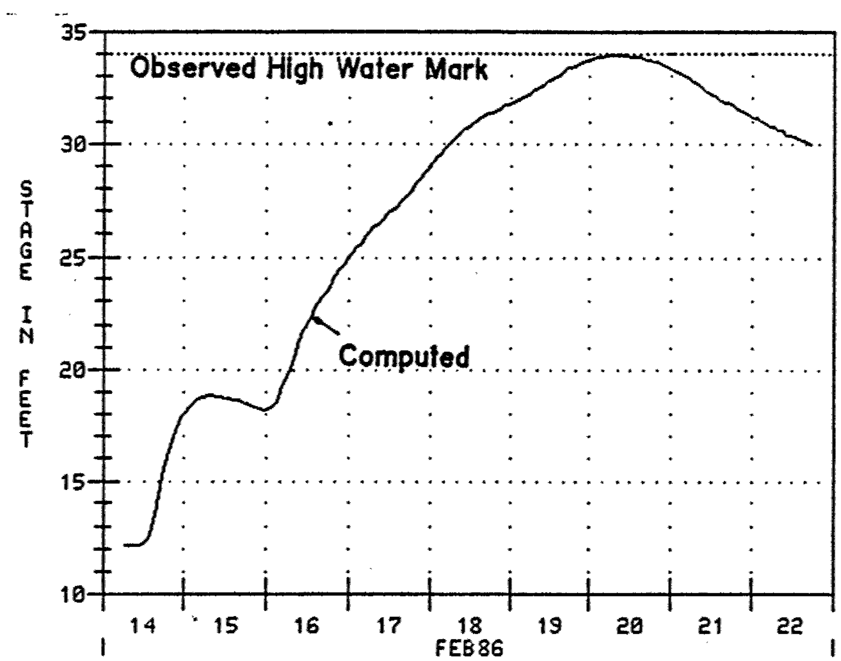
1986 COMPUTED & OBSERVED HYDROGRAPHS

NATOMAS EAST MAIN DRAINAGE CANAL

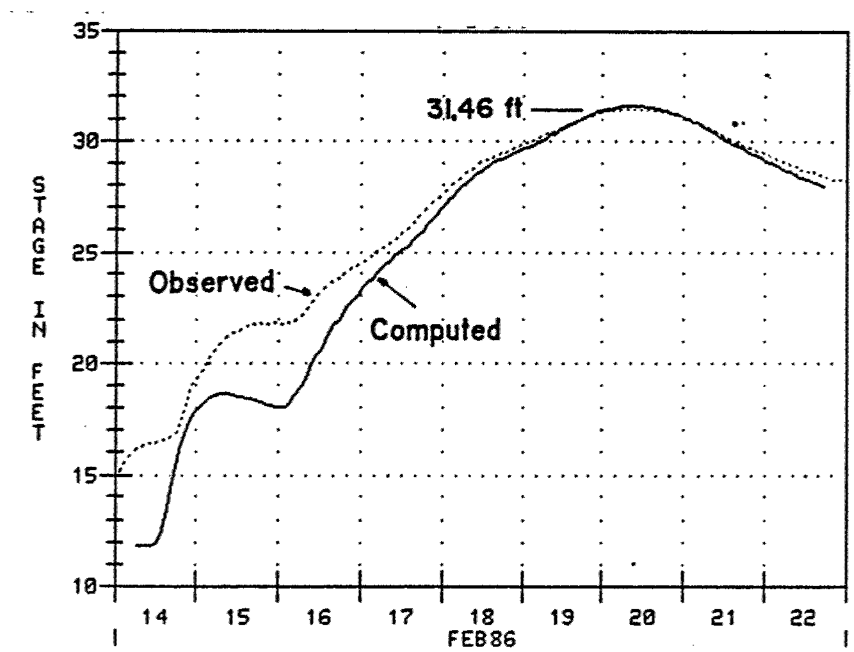
CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.

Date: JUNE 1990



AT KNIGHTS LANDINGS RIDGE CUT



AT WOODLAND

SACRAMENTO METRO INVESTIGATION

1986 COMPUTED & OBSERVED HYDROGRAPHS

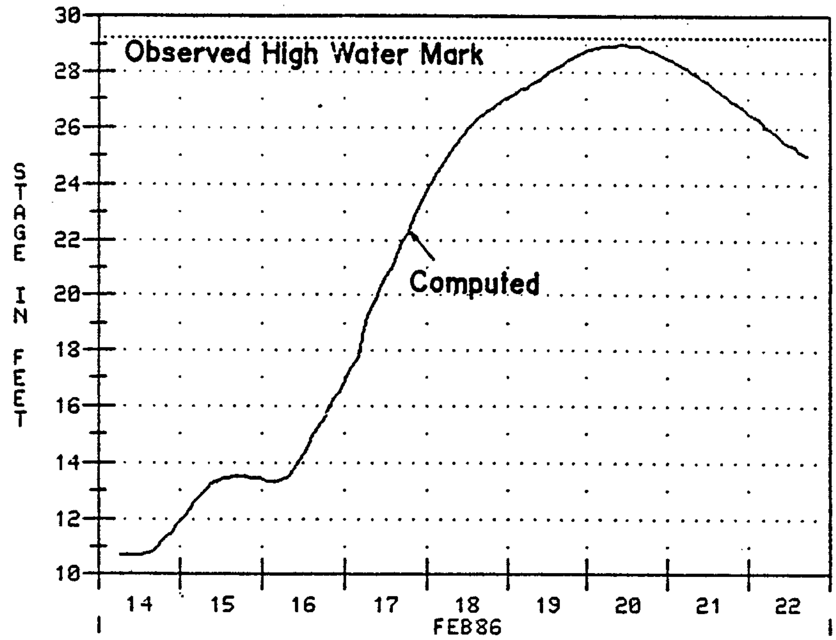
YOLO BYPASS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

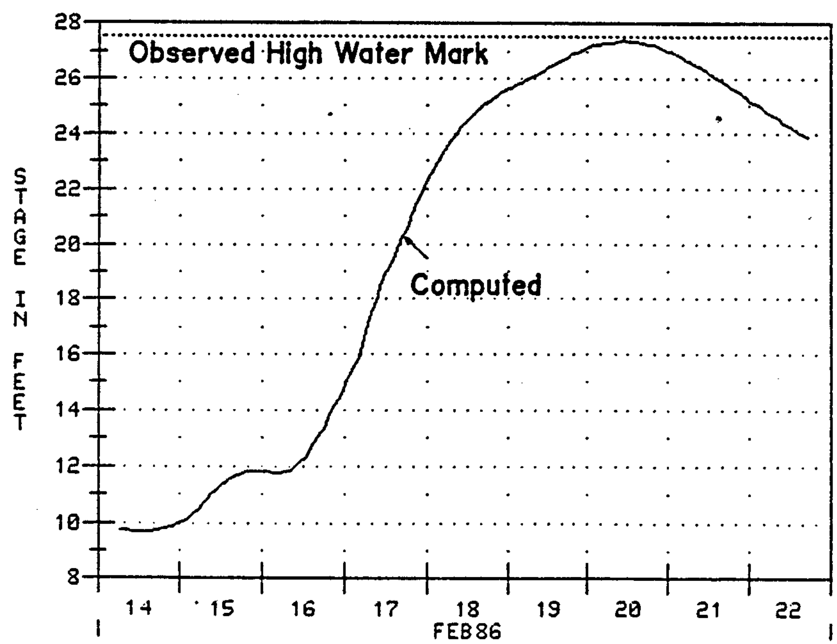
Prepared: J.H.
Drawn: J.H.

Date: JUNE 1990

SHEET 10 OF 11 CHART 20



AT D/S END OF SACRAMENTO BYPASS



AT SHIP CHANNEL

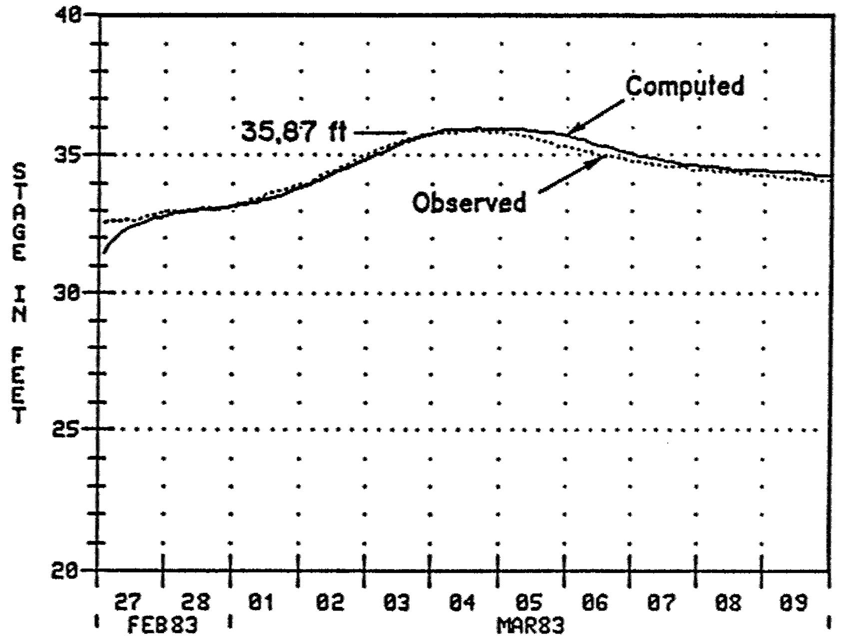
SACRAMENTO METRO INVESTIGATION

1986 COMPUTED & OBSERVED HYDROGRAPHS

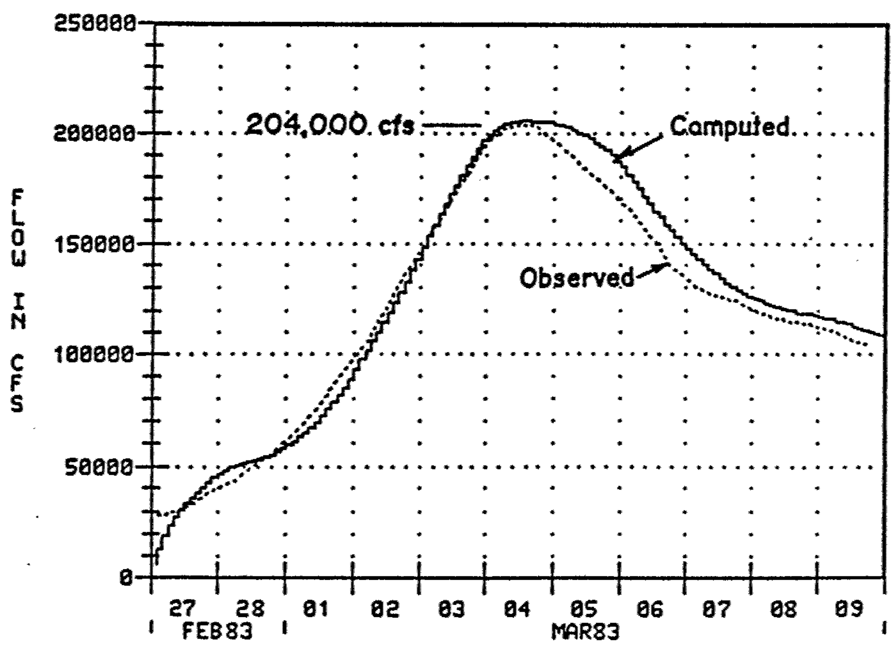
YOLO BYPASS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990



SACRAMENTO RIVER @ FREMONT WEIR WEST END



FREMONT WEIR SPILL TO YOLO BYPASS

SACRAMENTO METRO INVESTIGATION

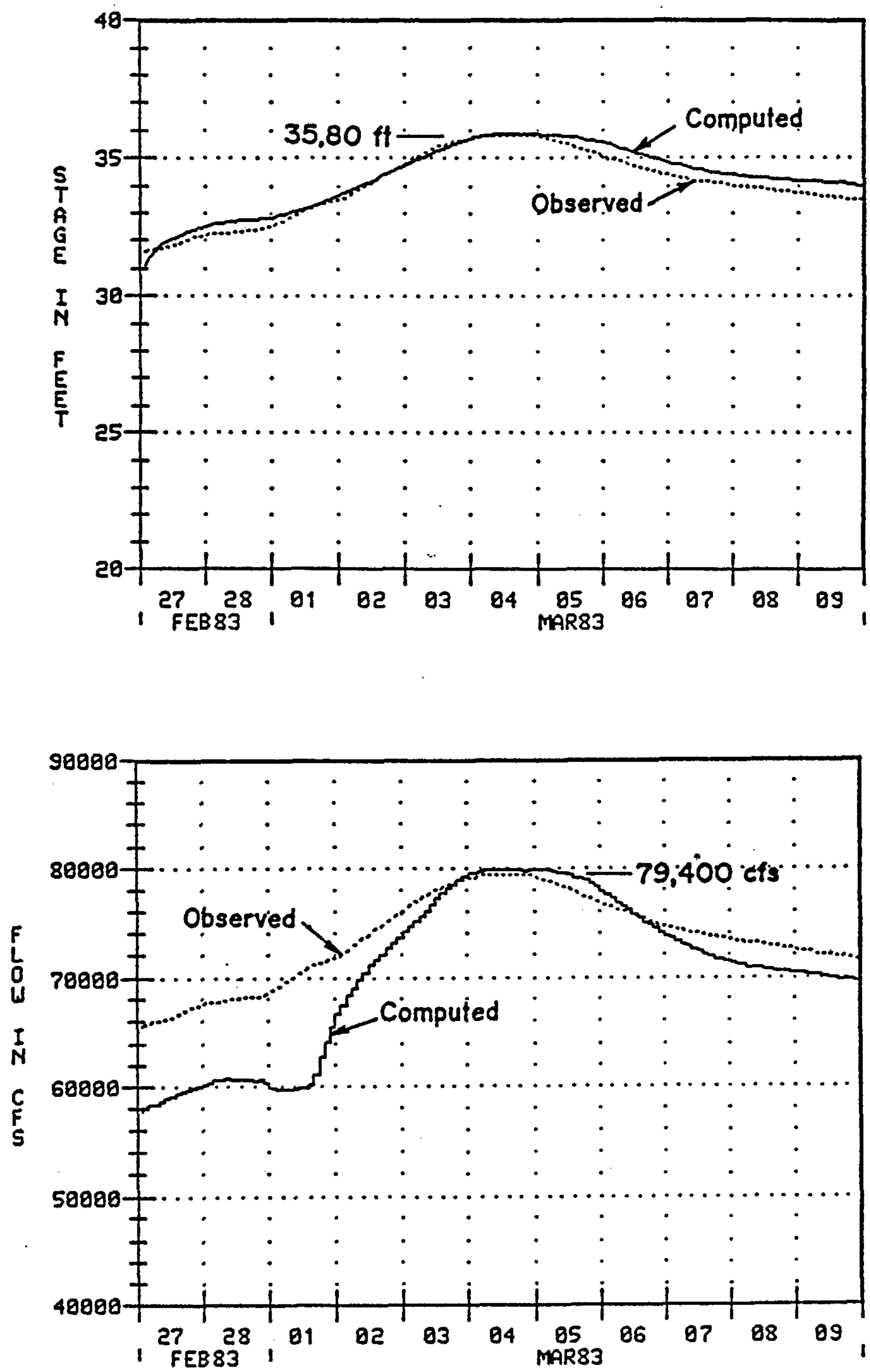
1983 COMPUTED & OBSERVED HYDROGRAPHS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.

Date: JUNE 1990

SHEET 1 OF 5 CHART 21



SACRAMENTO METRO INVESTIGATION

1983 COMPUTED & OBSERVED HYDROGRAPHS

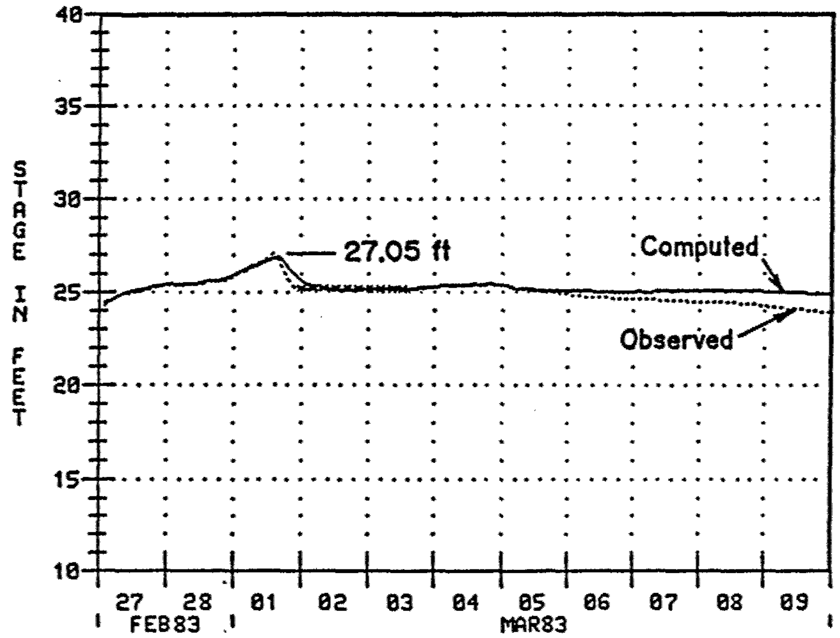
SACRAMENTO RIVER @ VERONA

CORPS OF ENGINEERS. SACRAMENTO CALIFORNIA

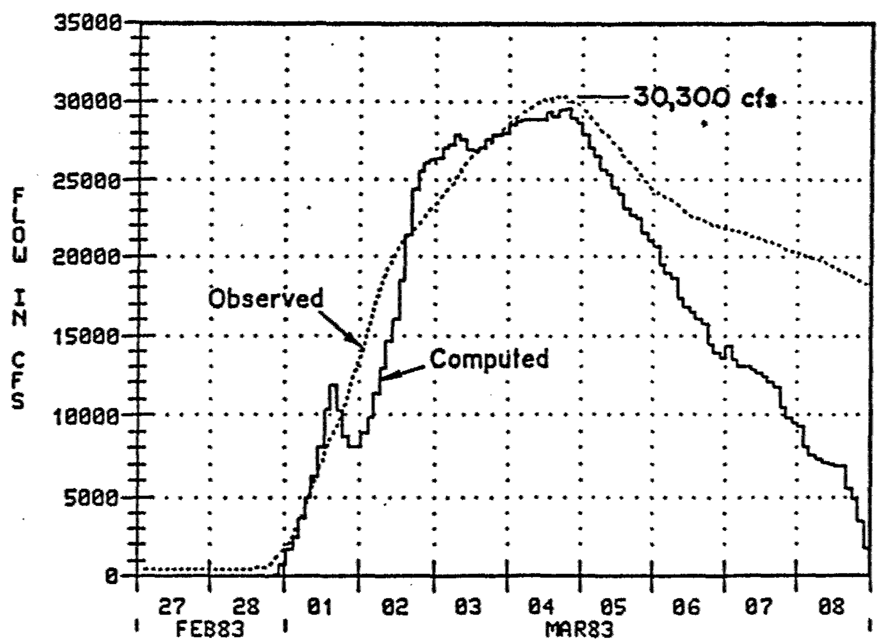
Prepared: J.H.
Drawn: C.A.P.

Date: JUNE 1990

SHEET 2 OF 5 CHART 21



SACRAMENTO R. @ U/S END OF SACRAMENTO WEIR



SACRAMENTO WEIR SPILL TO YOLO BYPASS

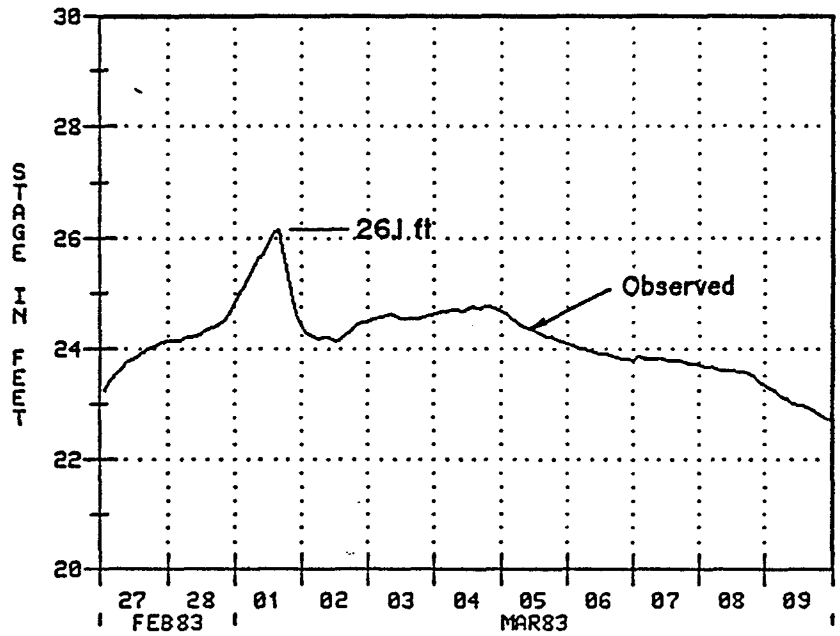
SACRAMENTO METRO INVESTIGATION

1983 COMPUTED & OBSERVED HYDROGRAPHS

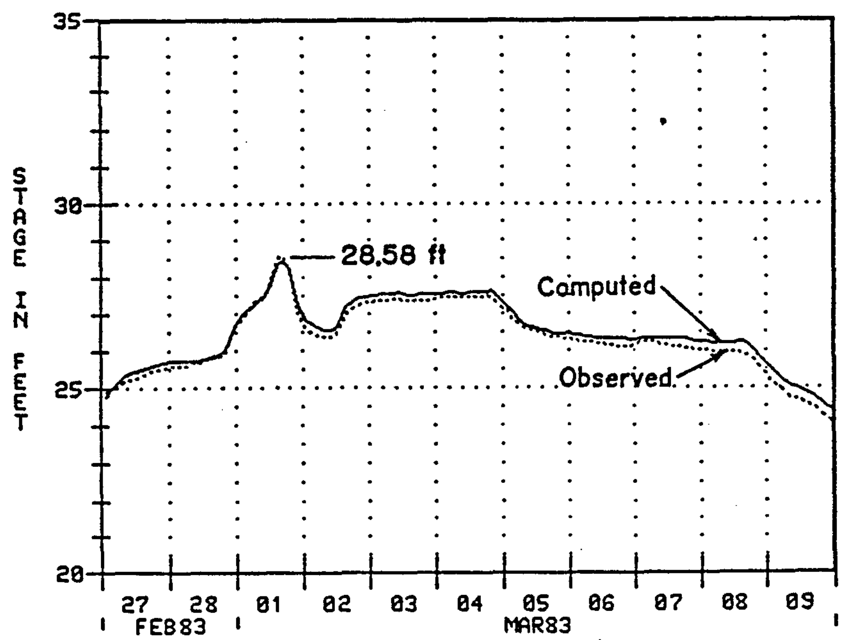
CORPS OF ENGINEERS, SACRAMENTO CALIFORNIA

Prepared: J.H. Drawn: C.A.P.	Date: JUNE 1990

SHEET 3 OF 5 CHART 21



SACRAMENTO RIVER @ I-STREET



AMERICAN RIVER @ H-STREET

SACRAMENTO METRO INVESTIGATION

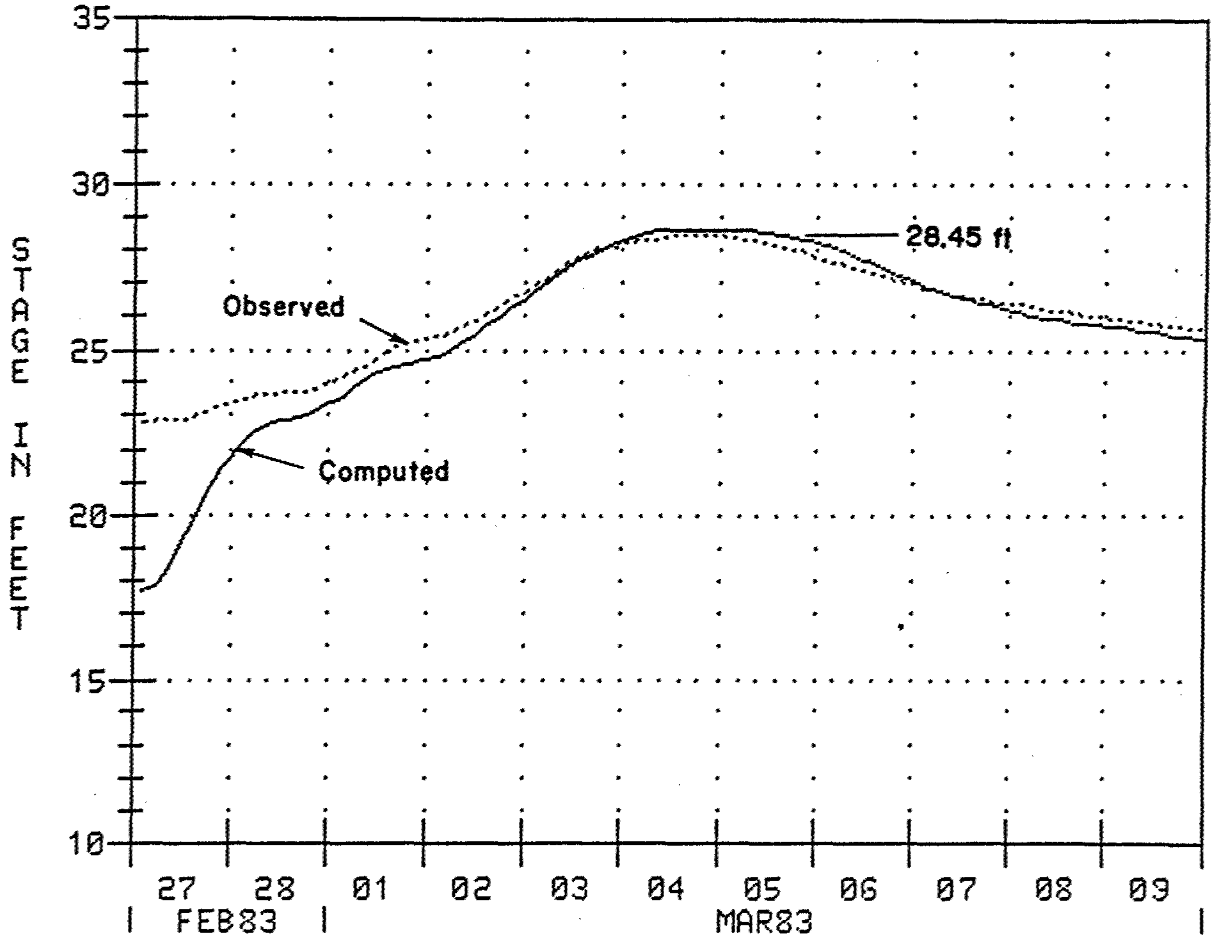
1983 COMPUTED & OBSERVED HYDROGRAPHS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.

Date: JUNE 1990

SHEET 4 OF 5 CHART 21



SACRAMENTO METRO INVESTIGATION

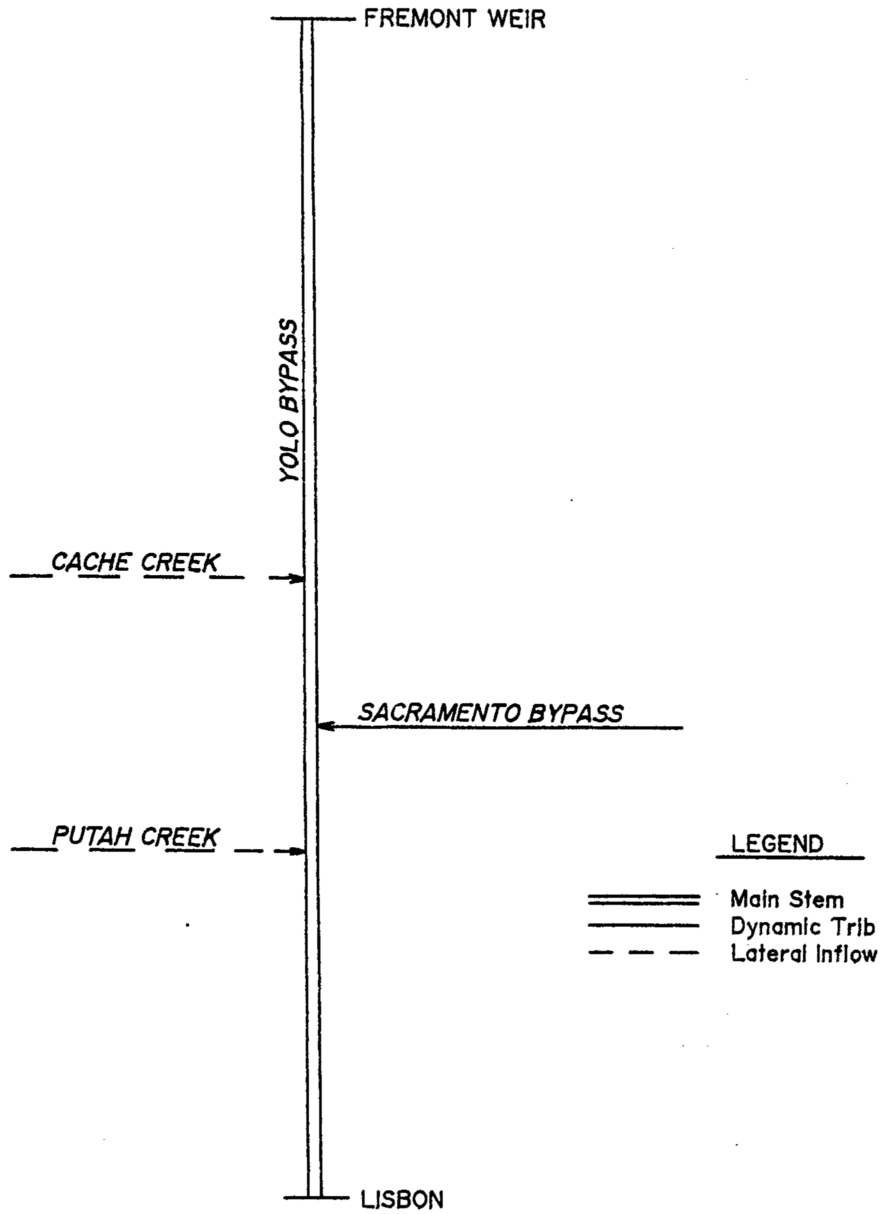
1983 COMPUTED & OBSERVED HYDROGRAPHS

YOLO BYPASS AT WOODLAN

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.
Date: JUNE 1990

SHEET 5 OF 5 CHART 21



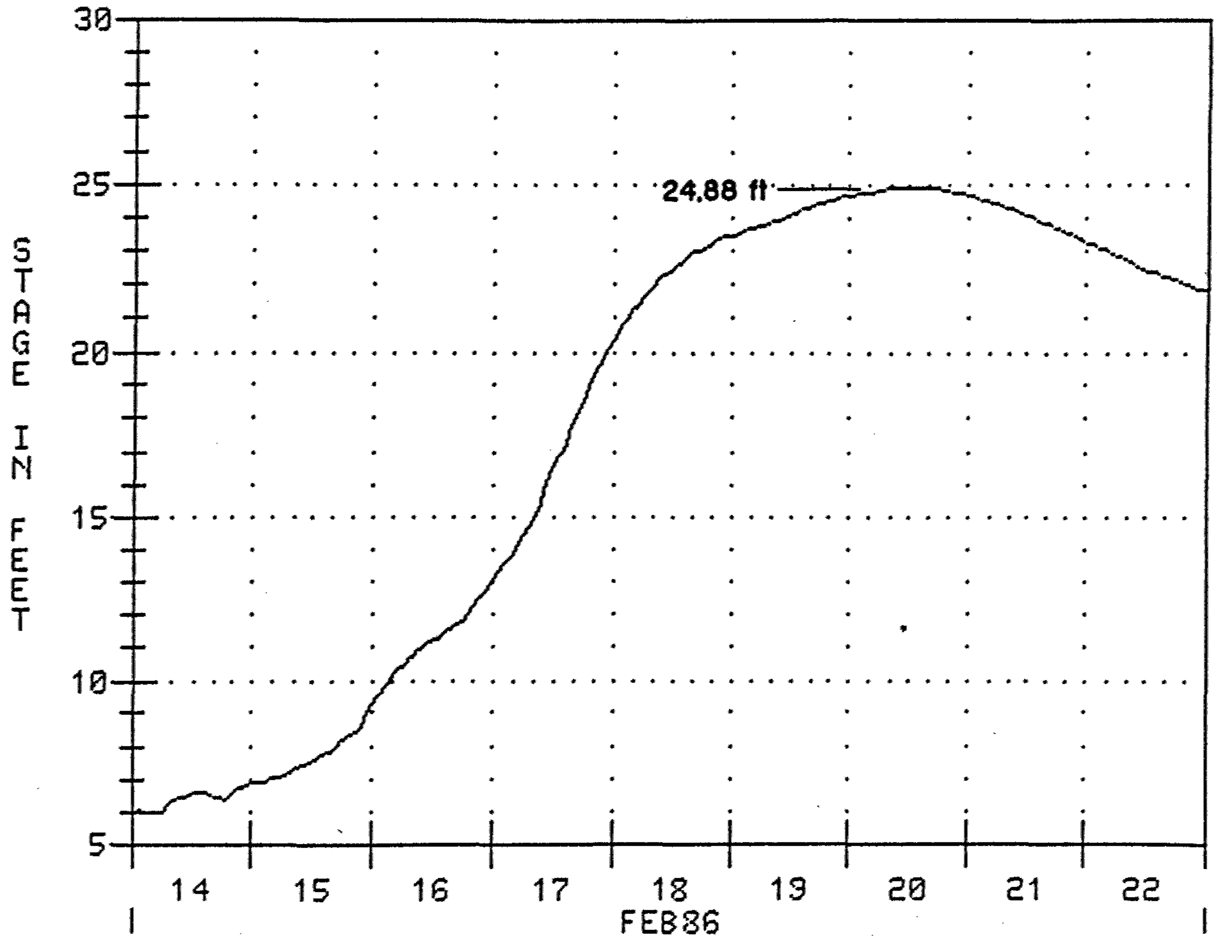
SACRAMENTO METRO INVESTIGATION

SCHEMATIC DIAGRAM
YOLO BYPASS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

CHART 22



SACRAMENTO METRO INVESTIGATION

1986 OBSERVED HYDROGRAPH

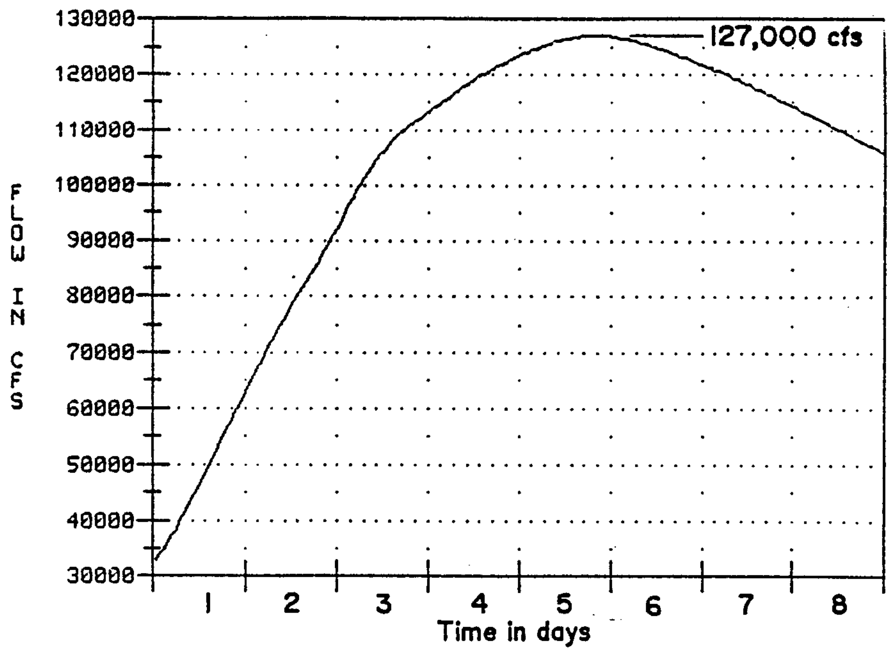
YOLO BYPASS AT LISBON

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

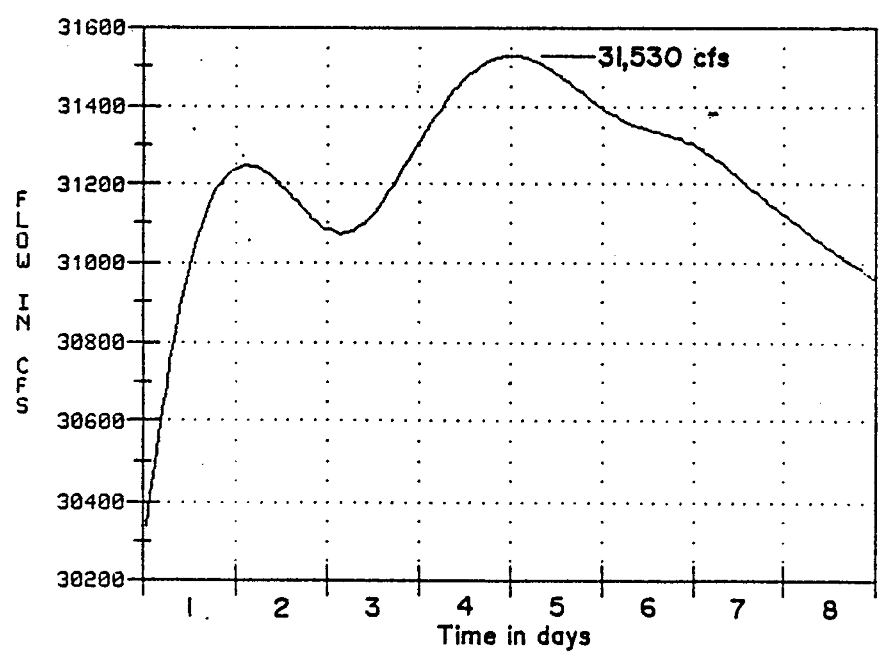
Prepared: J.H.
Drawn: C.A.P.

Date: JUNE 1990

CHART 23



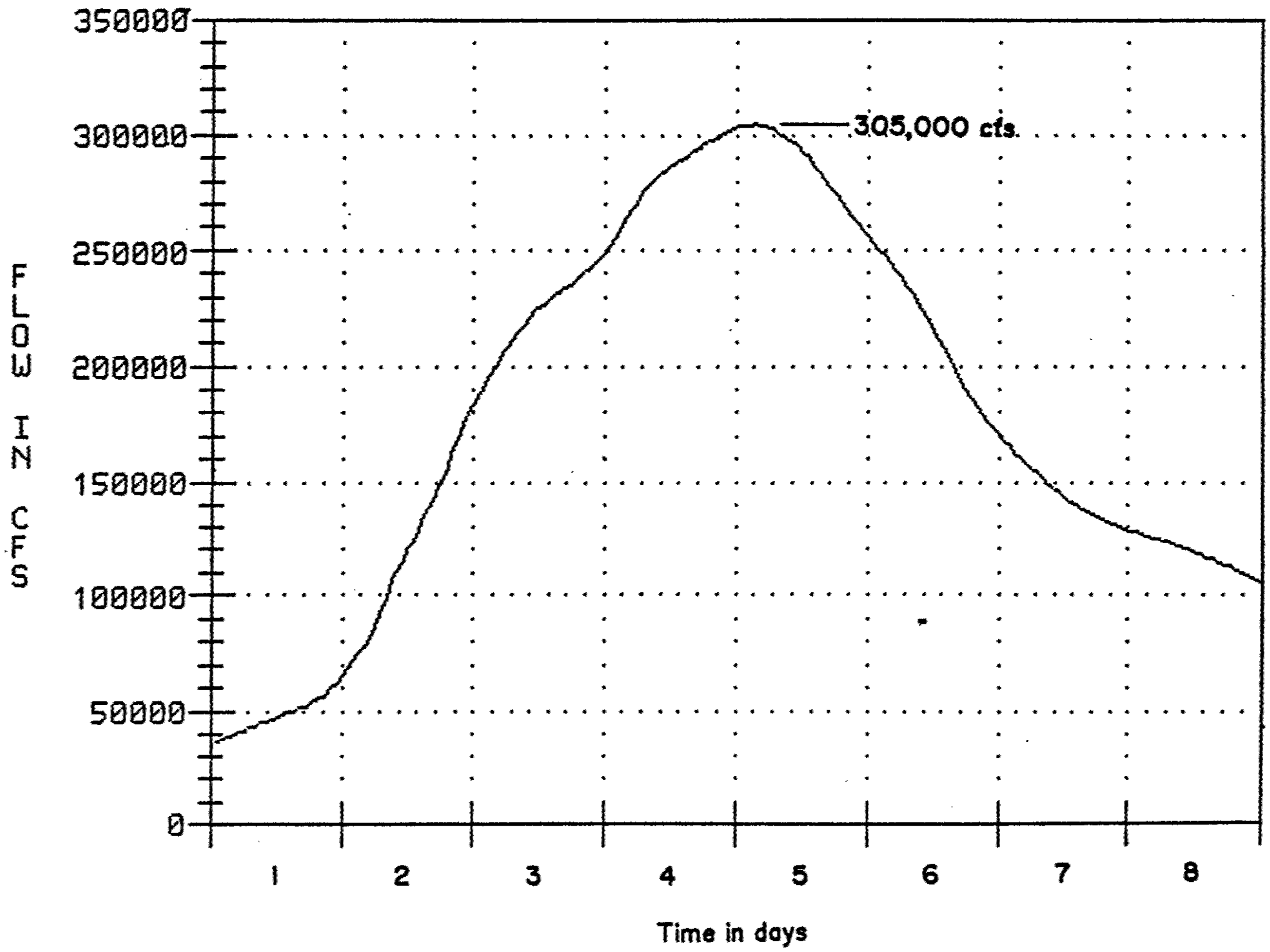
SUTTER BYPASS D/S TISDALE WEIR



SACRAMENTO RIVER @ WILKINS SL.

SACRAMENTO METRO INVESTIGATION	
100-YR. COMPUTED HYDROGRAPH	
CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA	
Prepared: J.H. Drawn: C.A.P.	Date: JUNE 1990

SHEET 1 OF 3 CHART 24



SACRAMENTO METRO INVESTIGATION

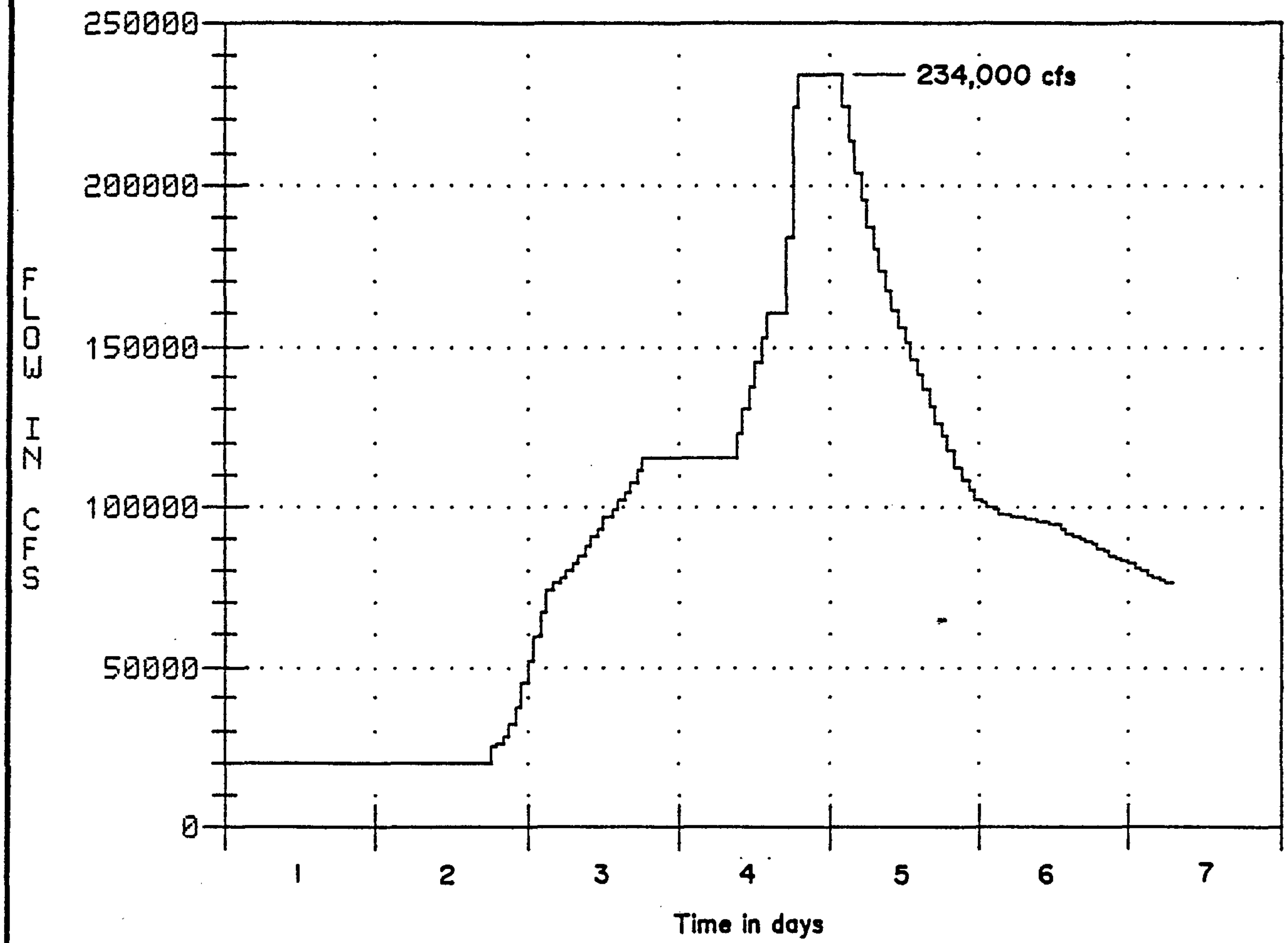
100-YR. COMPUTED HYDROGRAPH

FEATHER RIVER D/S BEAR RIVER

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.

Date: JUNE 1990



SACRAMENTO METRO INVESTIGATION

100-YR. COMPUTED HYDROGRAPH
PREPROJECT

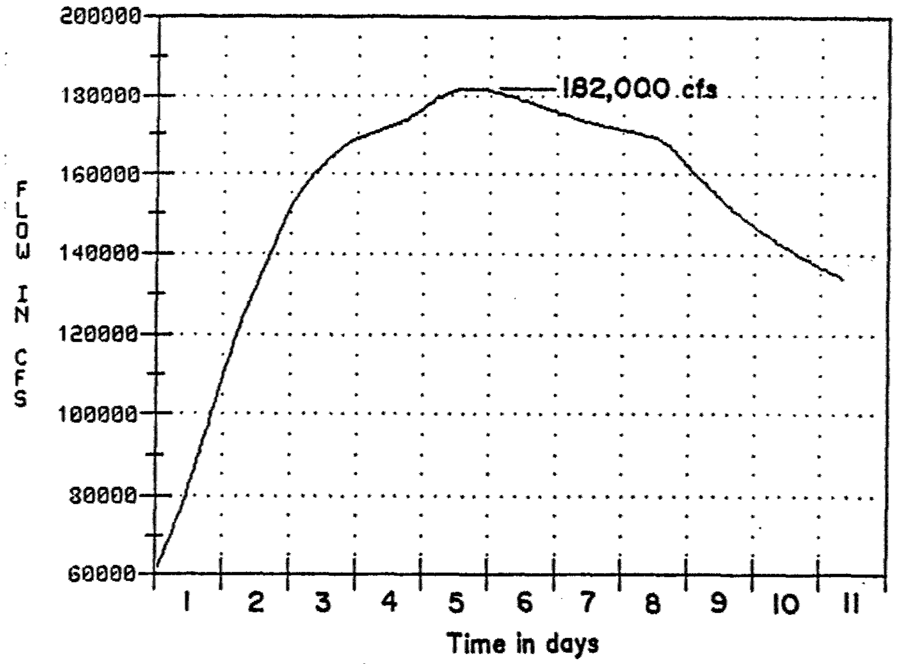
AMERICAN RIVER @ FAIR OAKS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

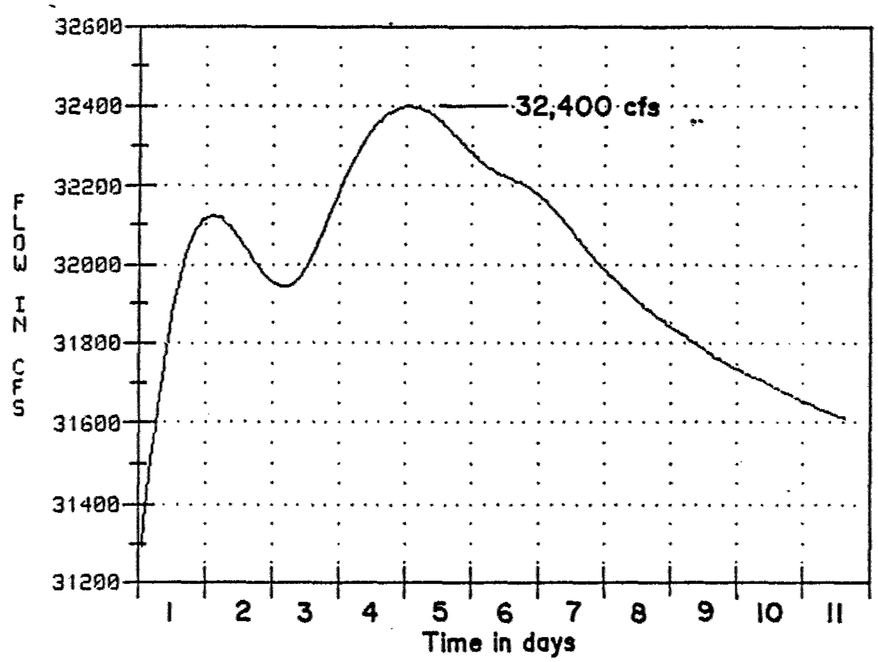
Prepared: J.H.
Drawn: C.A.P.

Date: JUNE 1990

SHEET 3 OF 3 CHART 24



SUTTER BYPASS D/S TISDALE WEIR



SACRAMENTO RIVER @ WILKINS SL.

SACRAMENTO METRO INVESTIGATION

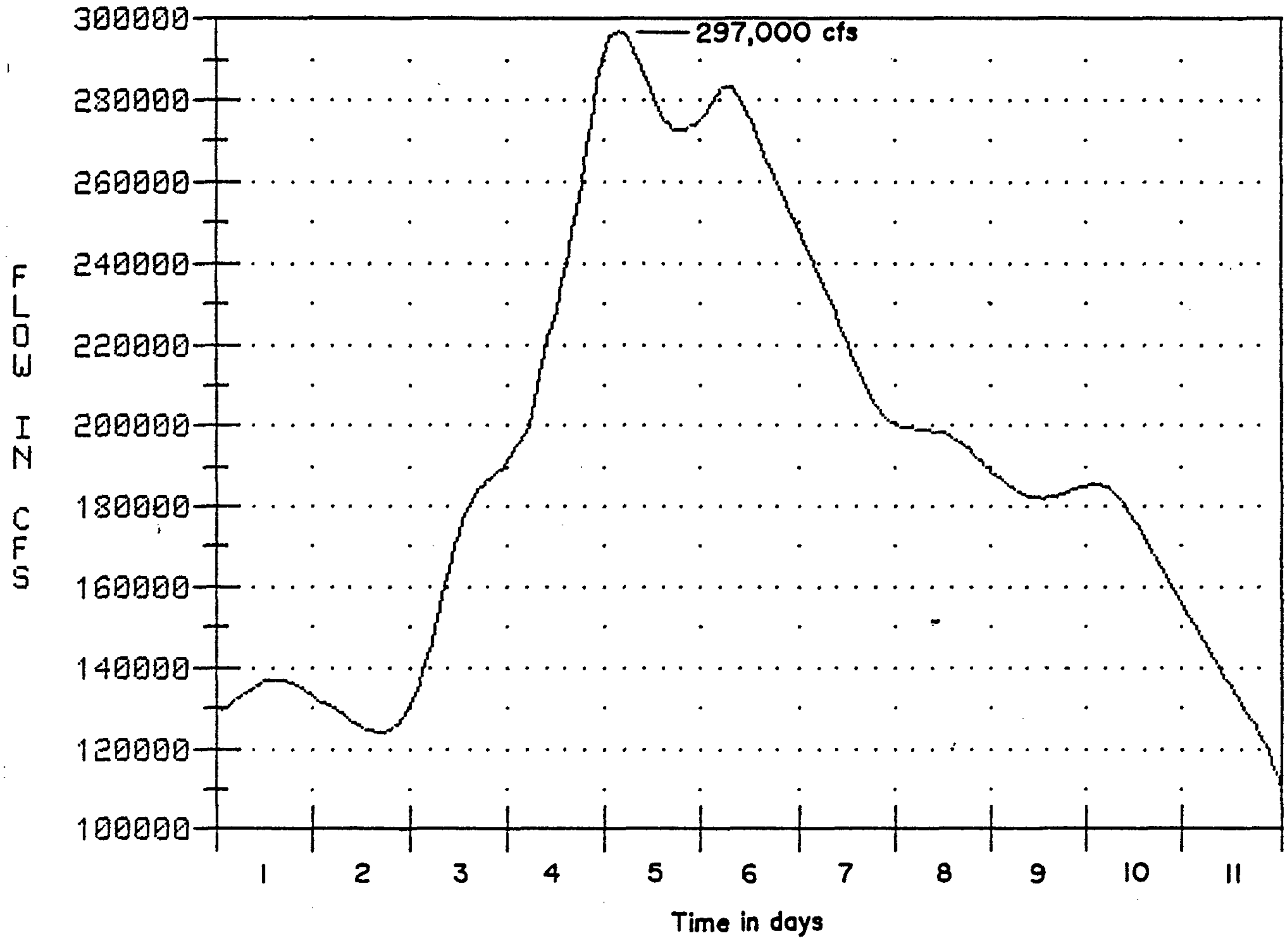
200-YR. COMPUTED HYDROGRAPH

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

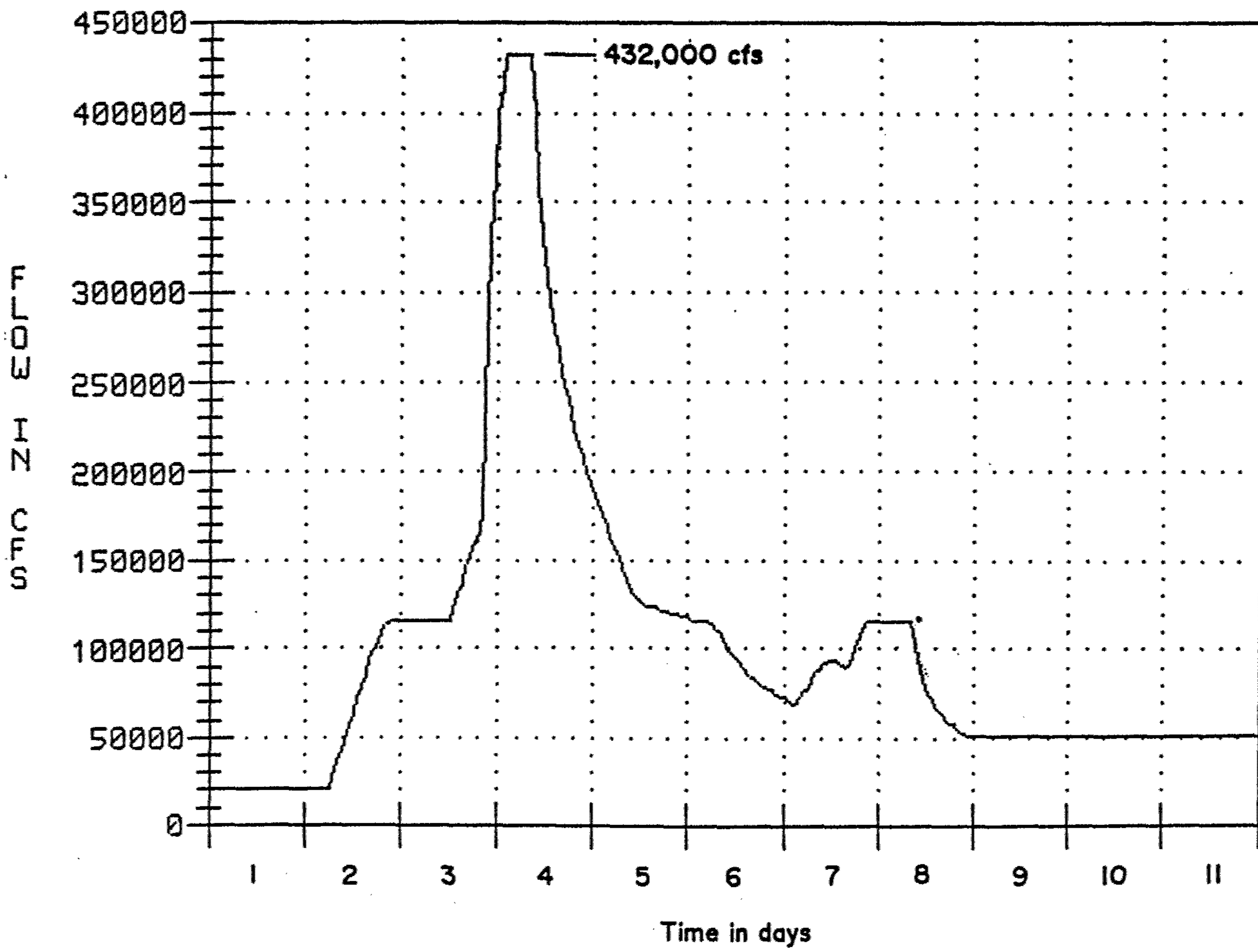
Prepared: J.H.
Drawn: C.A.P.

Date: JUNE 1990

SHEET 1 OF 3 CHART 25



SACRAMENTO METRO INVESTIGATION 200-YR. COMPUTED HYDROGRAPH FEATHER RIVER BELOW BEAR R.
CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: J.H. Drawn: C.A.P. Date: JUNE 1990



SACRAMENTO METRO INVESTIGATION

200-YR. COMPUTED HYDROGRAPH PREPROJECT

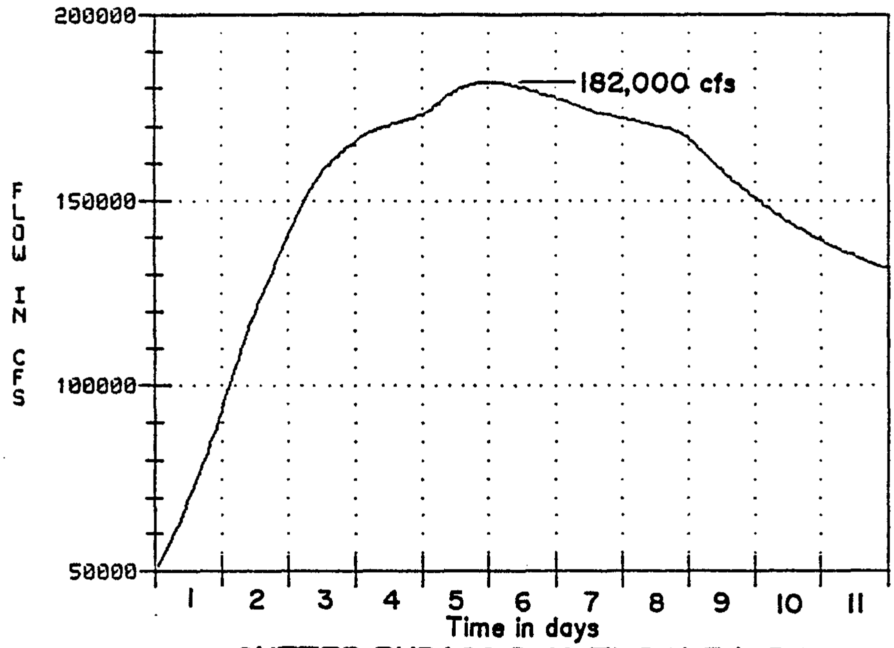
AMERICAN RIVER @ FAIR OAKS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

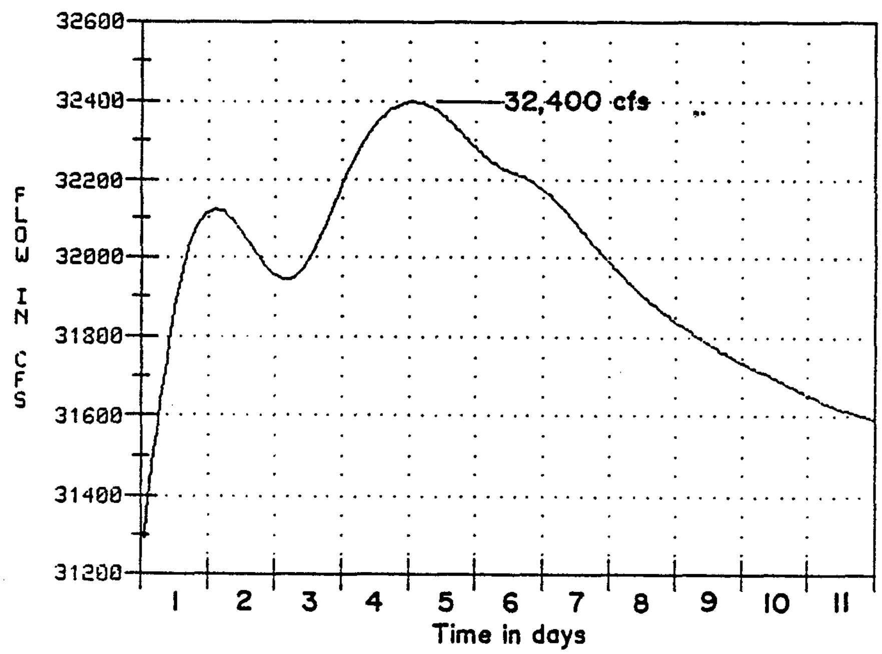
Prepared: J.H.
Drawn: C.A.P.

Date: JUNE 1990

SHEET 3 OF 3 CHART 25



SUTTER BYPASS D/S TISDALE WEIR



SACRAMENTO RIVER @ WILKINS SL.

SACRAMENTO METRO INVESTIGATION

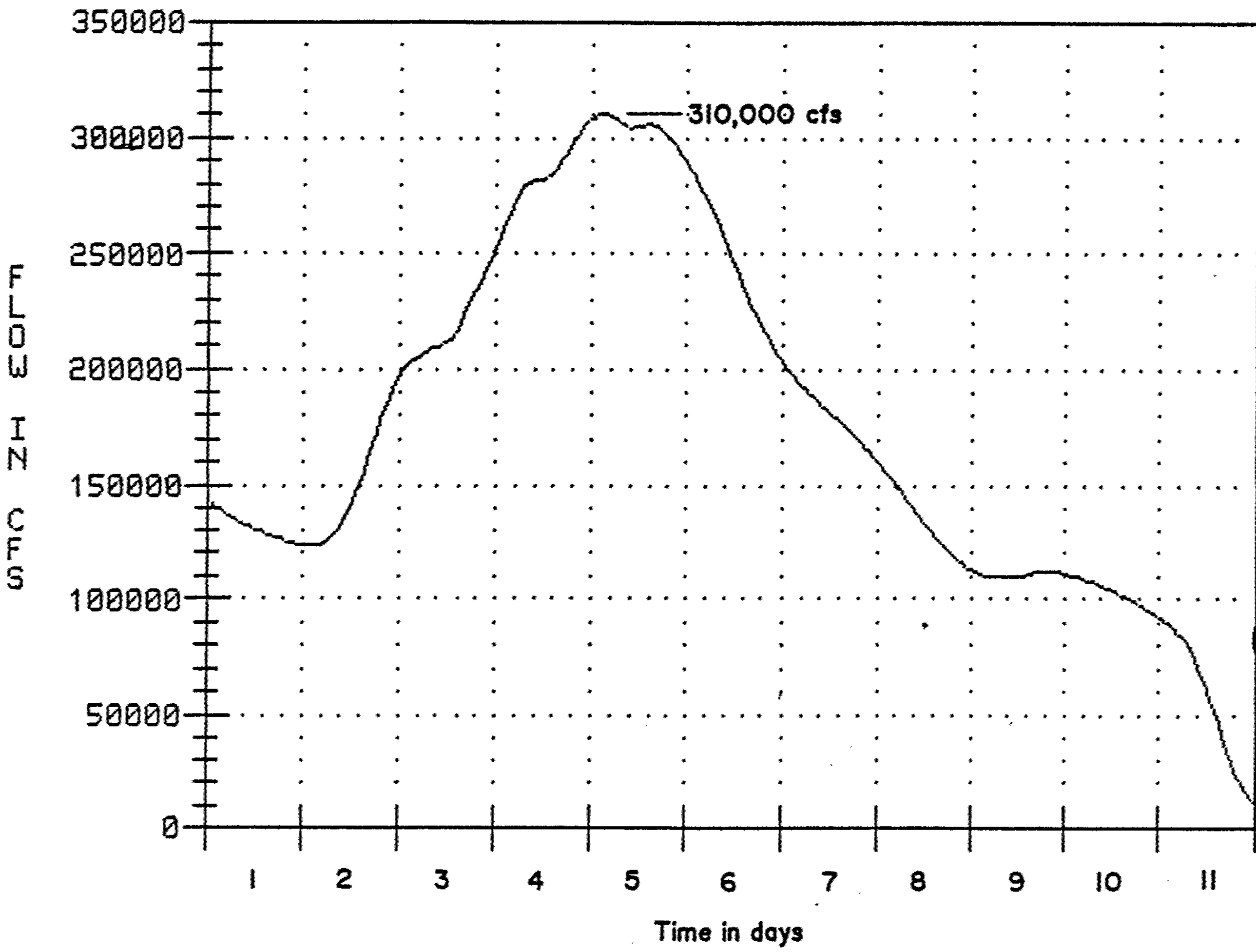
400-YR. COMPUTED HYDROGRAPH

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.

Date: JUNE 1990

SHEET 1 OF 3 CHART 26



SACRAMENTO METRO INVESTIGATION

400-YR. COMPUTED HYDROGRAPH

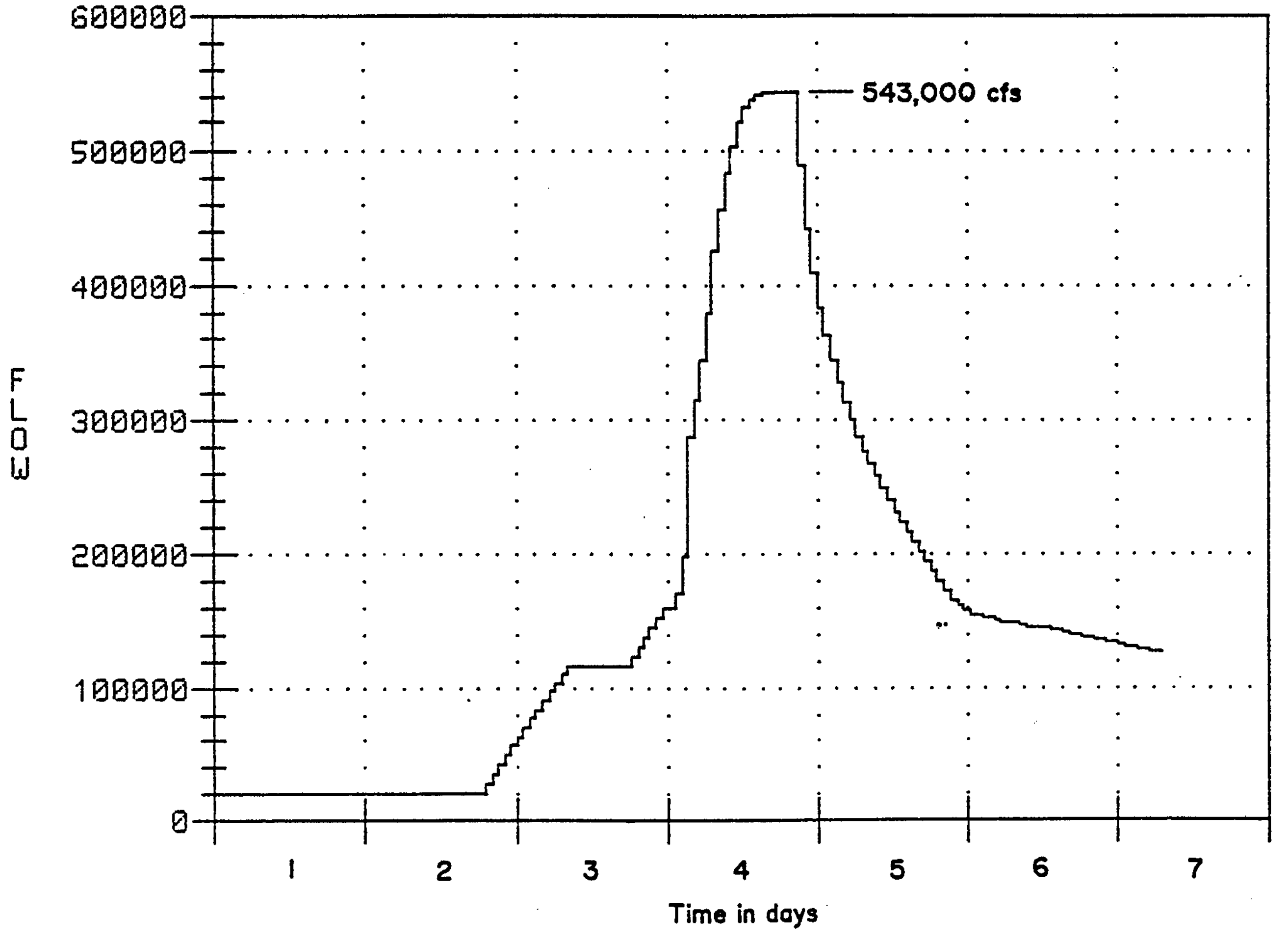
FEATHER RIVER BELOW BEAR R.

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.

Date: JUNE 1990

SHEET 2 OF 3 CHART 26



SACRAMENTO METRO INVESTIGATION

400-YR. COMPUTED HYDROGRAPH
PREPROJECT

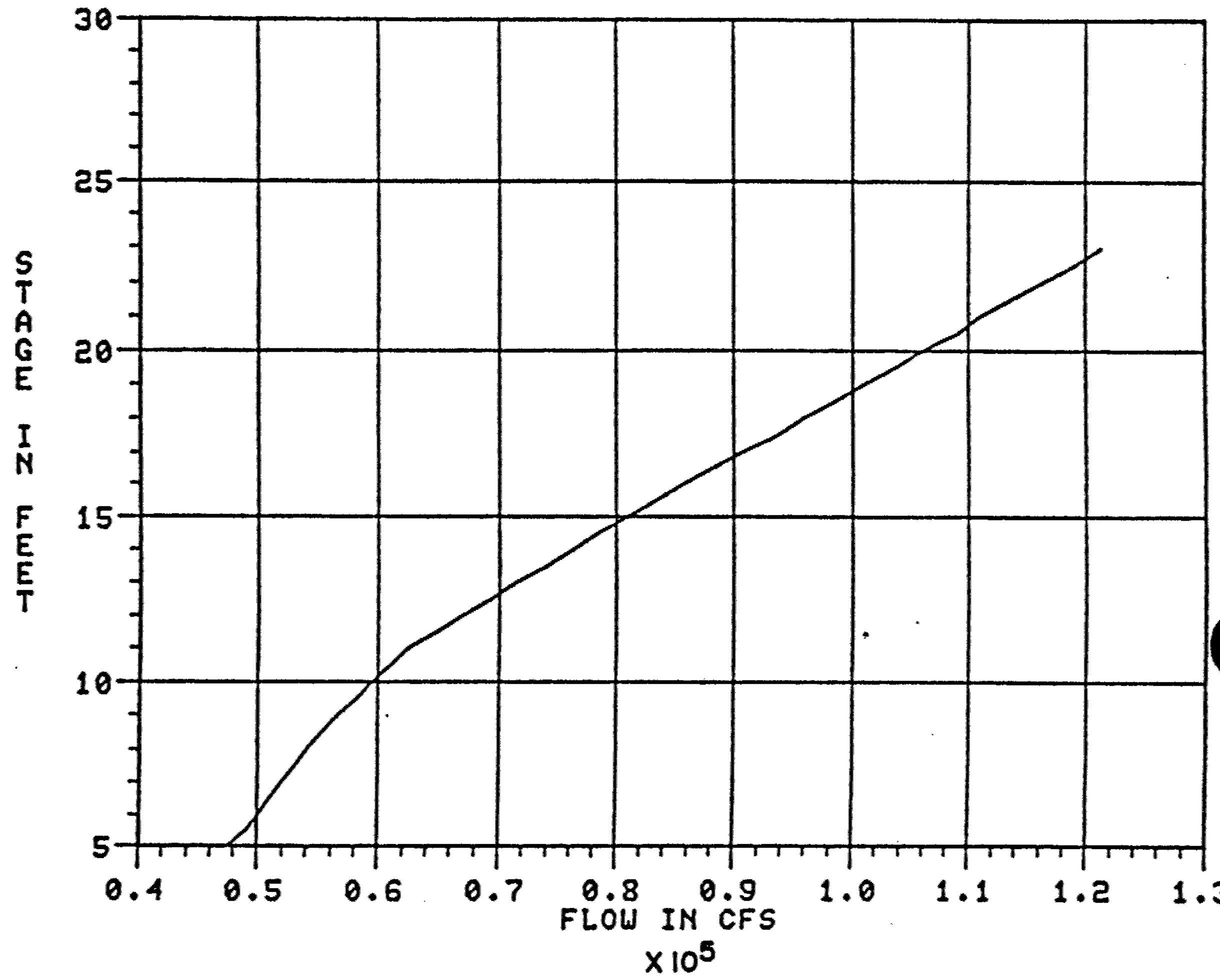
AMERICAN RIVER @ FAIR OAKS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.

Date: JUNE 1990

SHEET 3 OF 3 CHART 26



SACRAMENTO METRO INVESTIGATION

RATING CURVE

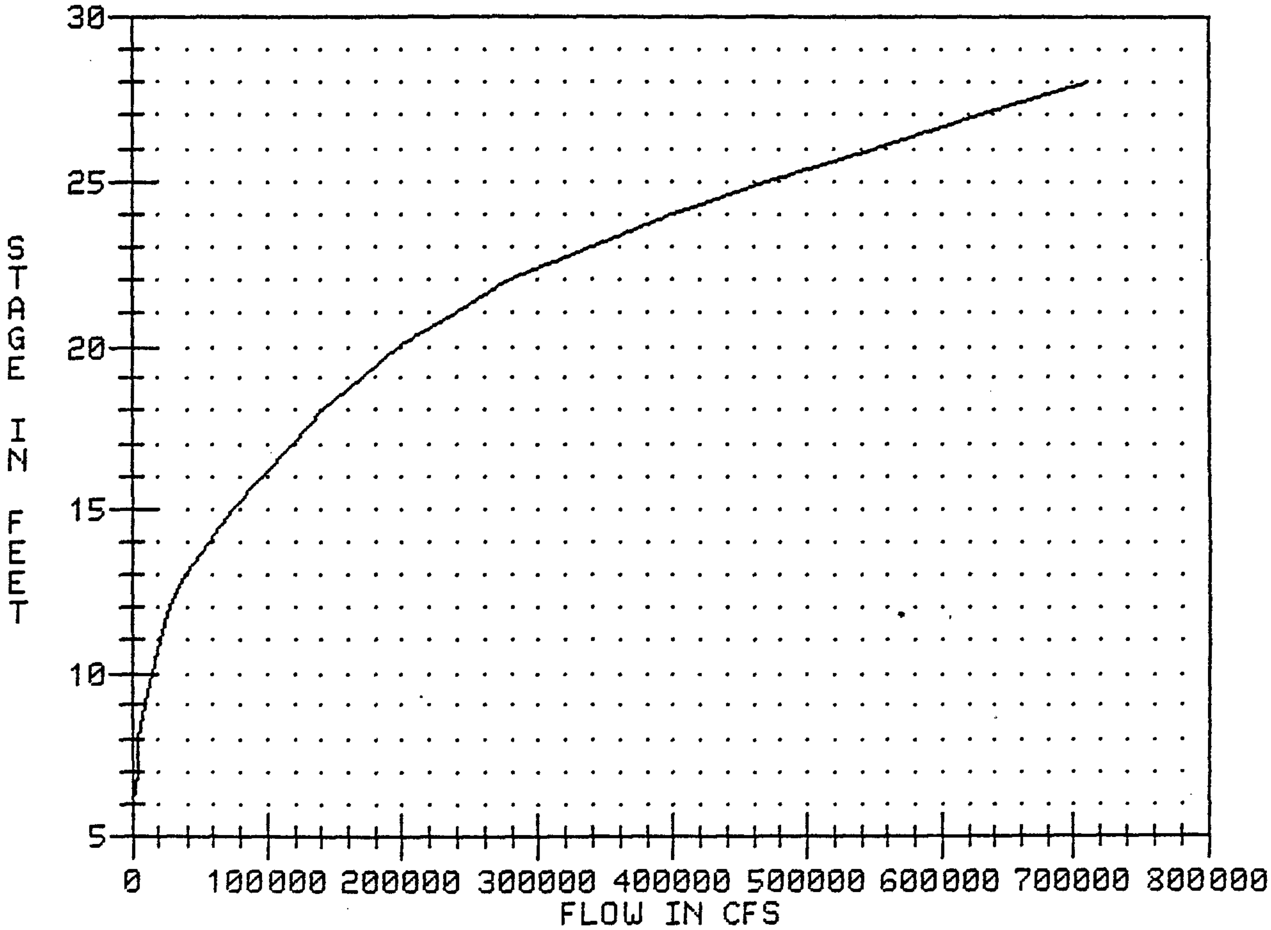
SACRAMENTO RIVER @ SNODGRASS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.

Date: JUNE 1990

CHART 27



SACRAMENTO METRO INVESTIGATION

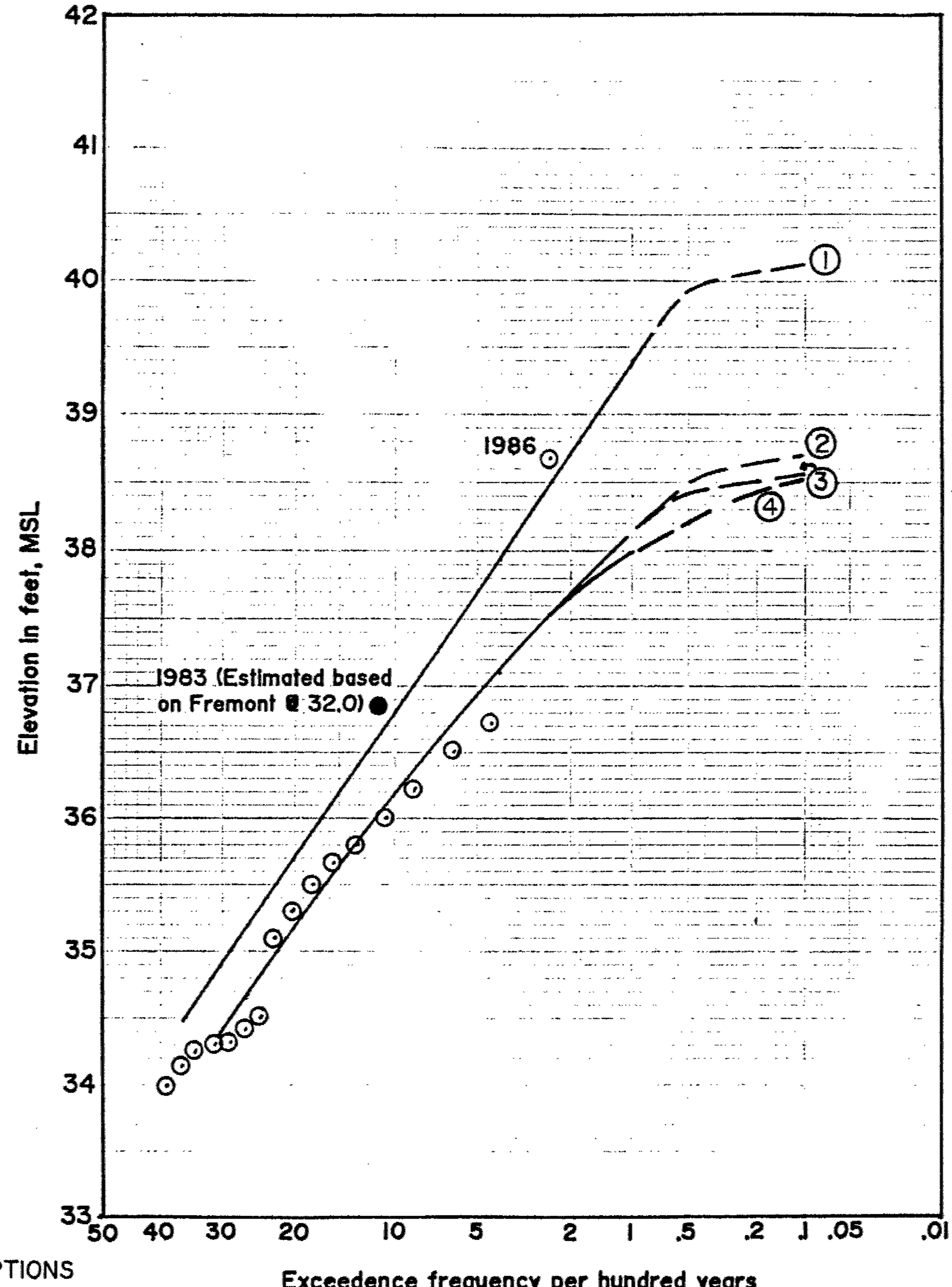
RATING CURVE

YOLO BYPASS AT LISBON

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: C.A.P.
Date: JUNE 1990

CHART 28



CURVE	ASSUMPTIONS USED
1	1, 7
2	2, 4, 7
3	2, 4, 9
4	3, 10

ASSUMPTIONS

1. Fremont Weir @ 32.0
2. Fremont Weir @ 31.0
3. Fremont Weir @ 30.5
4. Area C Failure
5. Return Flow From Area C
6. Sac River @ Mile 50 Failure
7. American River Failures
8. Yolo Bypass Failure to West Sacramento
9. American River at 115,000 cfs
10. South Levee Natomas Cross Canal Failure

SACRAMENTO METRO INVESTIGATION

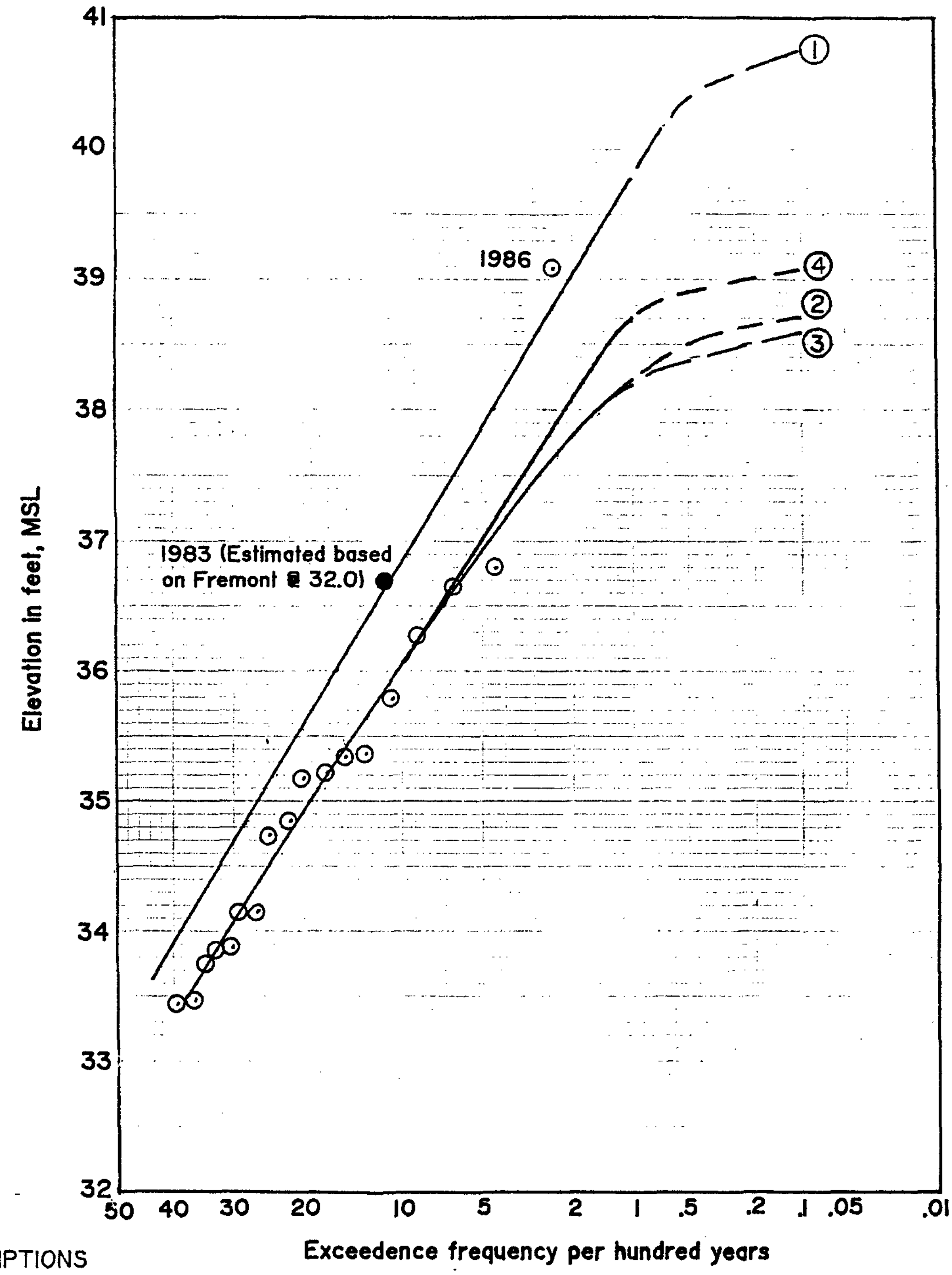
STAGE-FREQUENCY CURVES

SACRAMENTO RIVER @ FREMON
WEIR WEST END

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

CHART 29



CURVE	ASSUMPTIONS USED
1	1, 7.
2	2, 4, 7
3	2, 4, 9
4	3, 10

ASSUMPTIONS

1. Fremont Weir @ 32.0
2. Fremont Weir @ 31.0
3. Fremont Weir @ 30.5
4. Area C Failure
5. Return Flow From Area C
6. Sac River @ Mile 50 Failure
7. American River Failures
8. Yolo Bypass Failure to West Sacramento
9. American River at 115,000 cfs
10. South Levee Natomas Cross Canal Failure

SACRAMENTO METRO INVESTIGATION

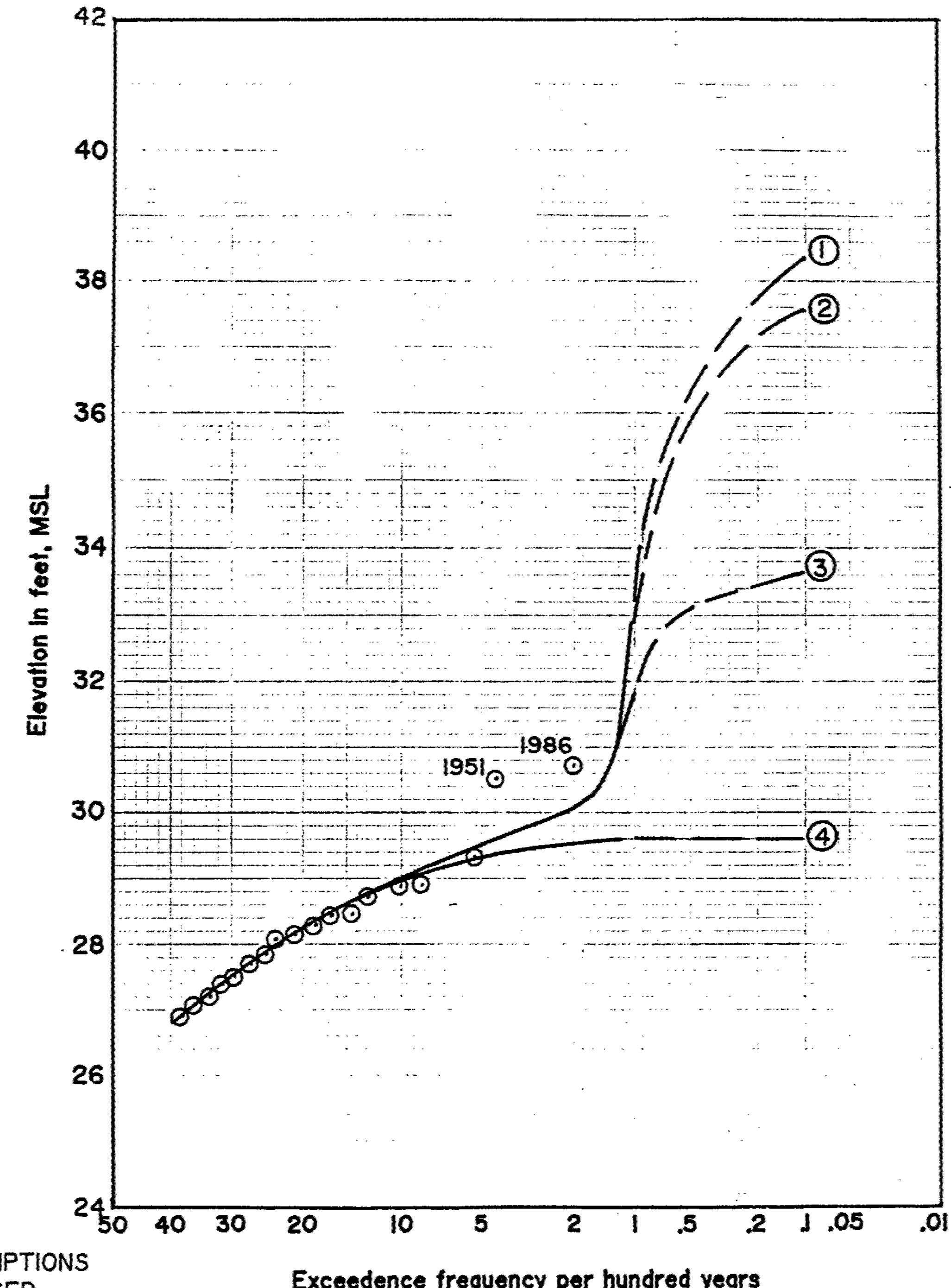
STAGE-FREQUENCY CURVES

SACRAMENTO RIVER @ VERONA

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

CHART 30



CURVE	ASSUMPTIONS USED
1	1, 7
2	2, 4, 7
3	2, 4, 6, 7
4	2, 4

ASSUMPTIONS

1. Fremont Weir @ 32.0
2. Fremont Weir @ 31.0
3. Fremont Weir @ 30.5
4. Area C Failure
5. Return Flow From Area C
6. Sac River @ Mile 50 Failure
7. American River Failures
8. Yolo Bypass Failure to West Sacramento
9. American River at 115,000 cfs
10. South Levee Natomas Cross Canal Failure

SACRAMENTO METRO INVESTIGATION

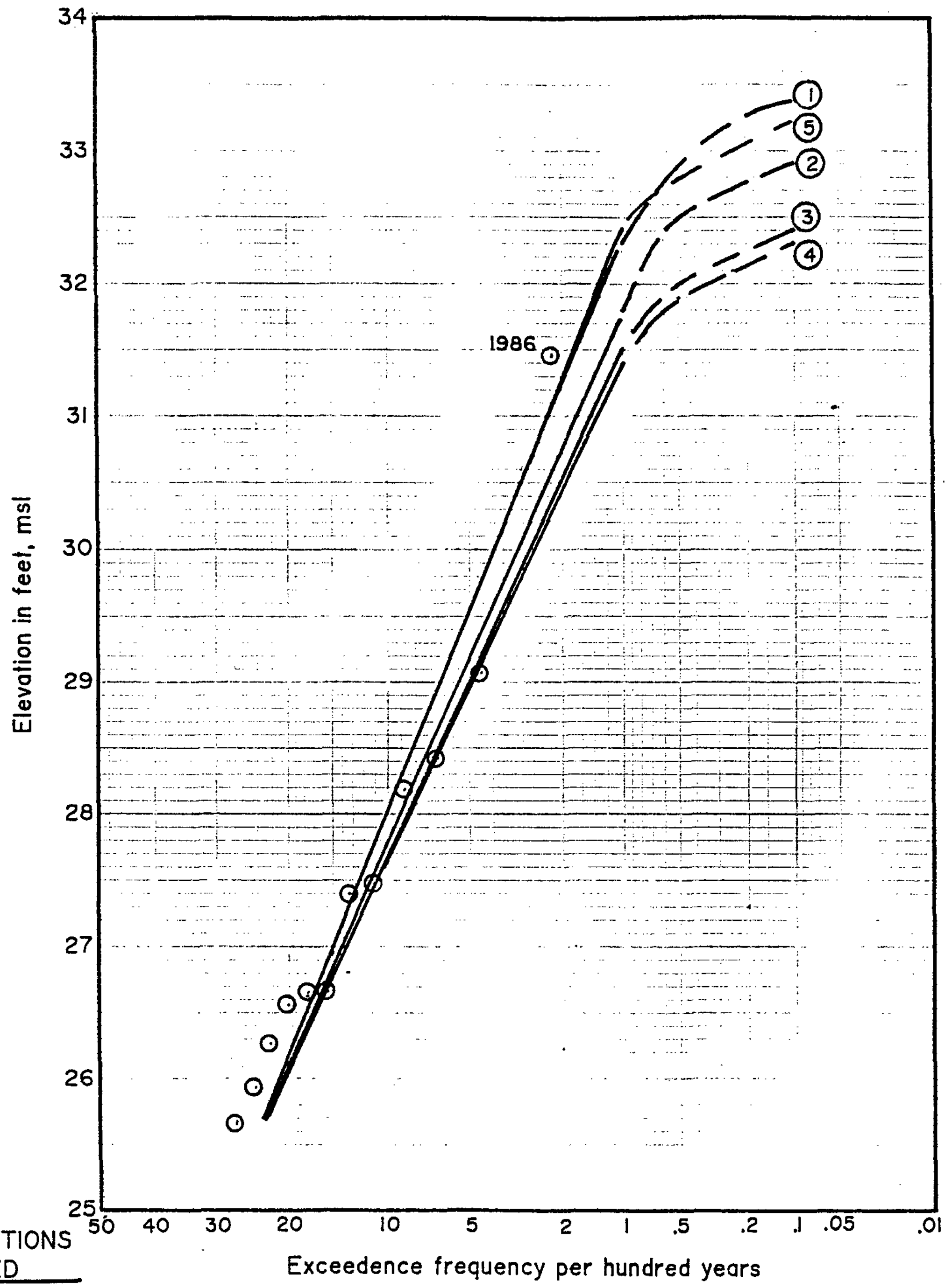
STAGE-FREQUENCY CURVES

SACRAMENTO RIVER @ I-STRE

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

CHART 31



CURVE	ASSUMPTIONS USED
1	1, 7
2	2, 4, 5 ,6 ,7
3	2, 4, 5, 6, 7, 8,
4	2, 4, 5, 8, 9
5	3, 7, 10

ASSUMPTIONS

1. Fremont Weir @ 32.0
2. Fremont Weir @ 31.0
3. Fremont Weir @ 30.5
4. Area C Failure
5. Return Flow From Area C
6. Sac River @ Mile 50 Failure
7. American River Failures
8. Yolo Bypass Failure to West Sacramento
9. American River at 115,000 cfs
10. South Levee Natomas Cross Canal Failure

SACRAMENTO METRO INVESTIGATION

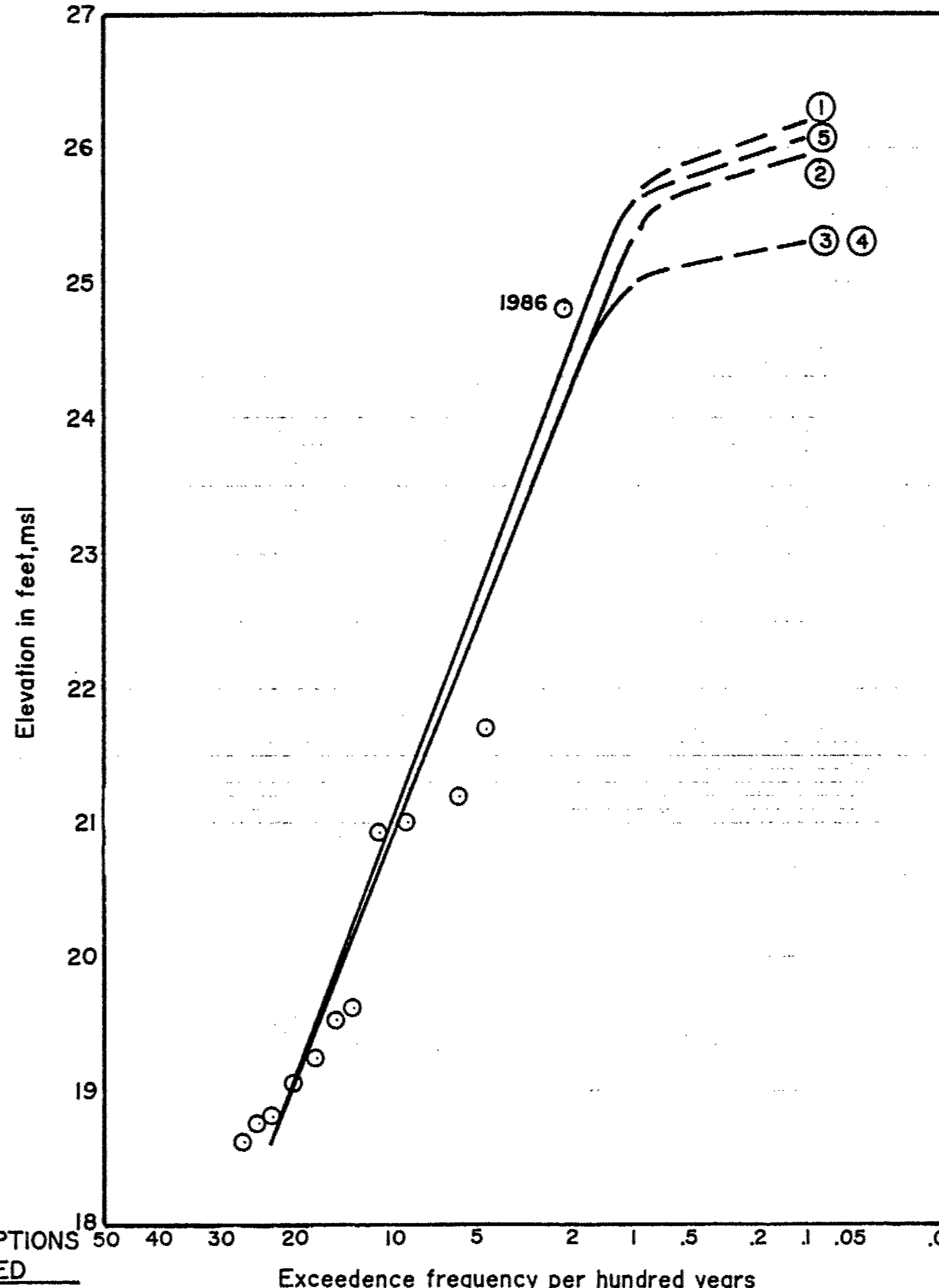
STAGE-FREQUENCY CURVES

YOLO BYPASS AT WOODLAND

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

CHART 32



CURVE	ASSUMPTIONS USED
1	1, 7
2	2, 4, 5, 6, 7
3	2, 4, 5, 6, 7, 8
4	2, 4, 5, 8, 9
5	3, 7, 10

ASSUMPTIONS

1. Fremont Weir @ 32.0
2. Fremont Weir @ 31.0
3. Fremont Weir @ 30.5
4. Area C Failure
5. Return Flow From Area C
6. Sac River @ Mile 50 Failure
7. American River Failures
8. Yolo Bypass Failure to West Sacramento
9. American River at 115,000 cfs
10. South Levee Natomas Cross Canal Failure

SACRAMENTO METRO INVESTIGATION

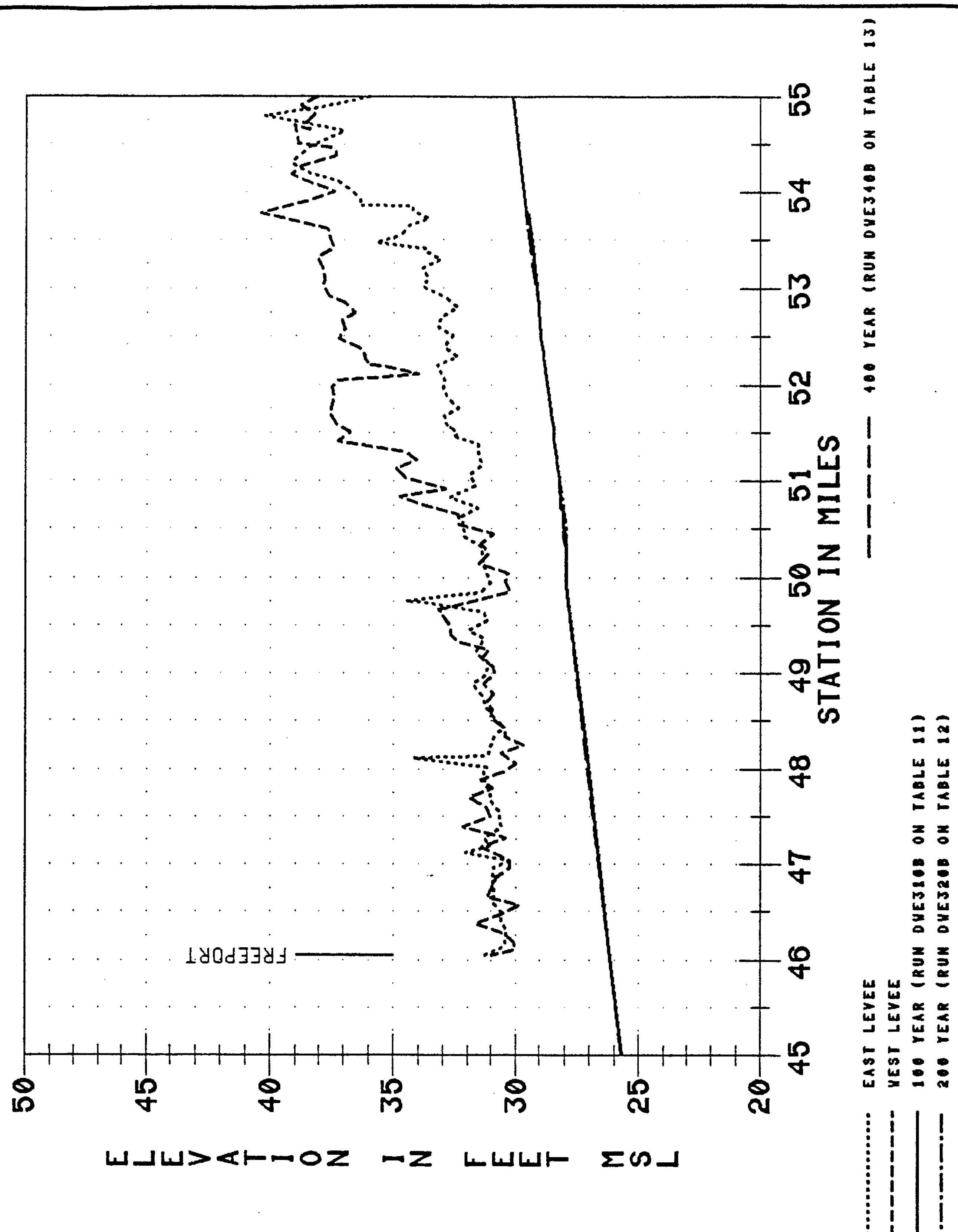
STAGE-FREQUENCY CURVES

YOLO BYPASS AT LISBON

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

CHART 33



SACRAMENTO METRO INVESTIGATION

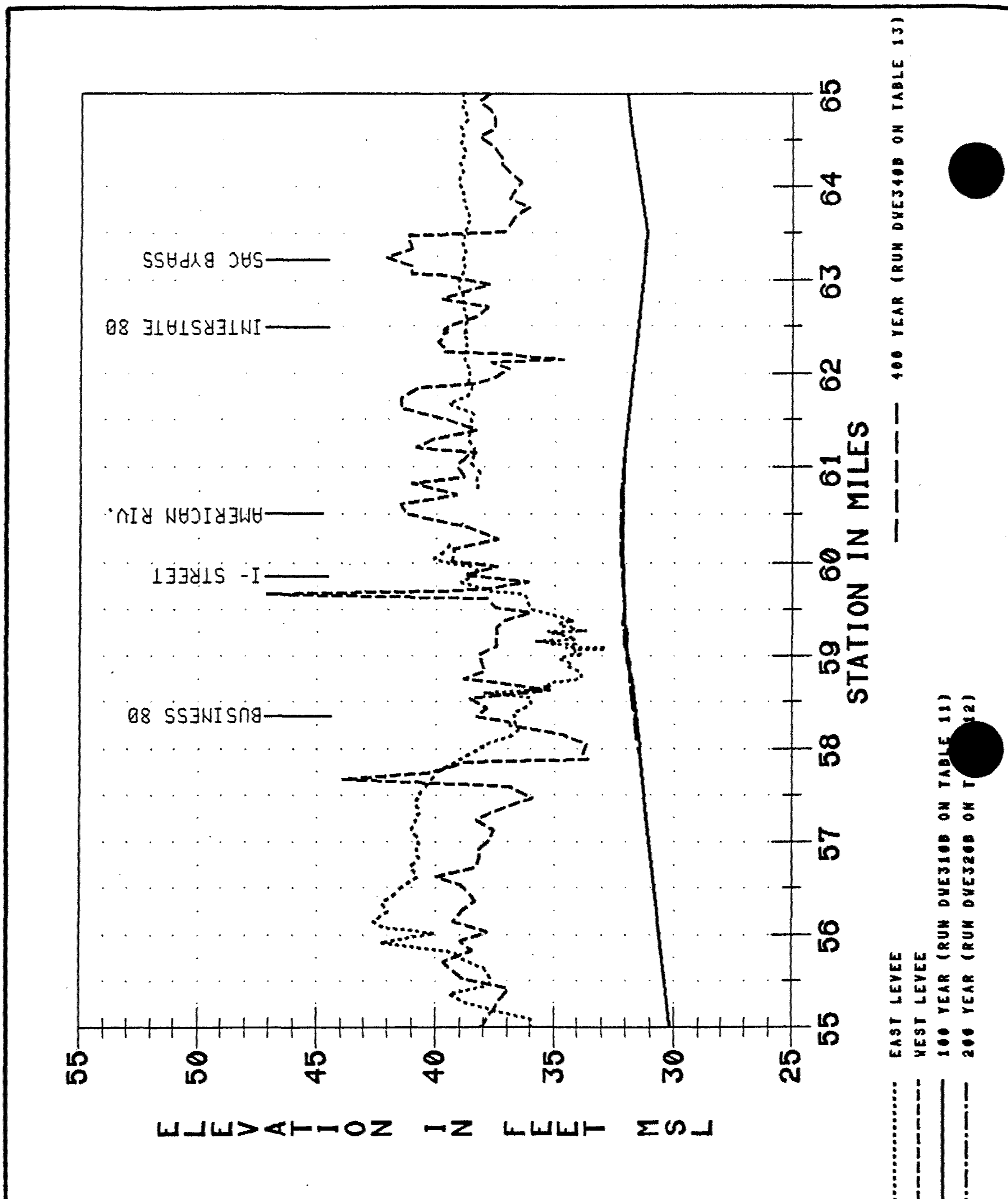
WATER SURFACE PROFILES
SACRAMENTO RIVER

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H.
Drawn: J.H.

Date: JUNE 1990

SHEET 1 OF 4 CHART 34



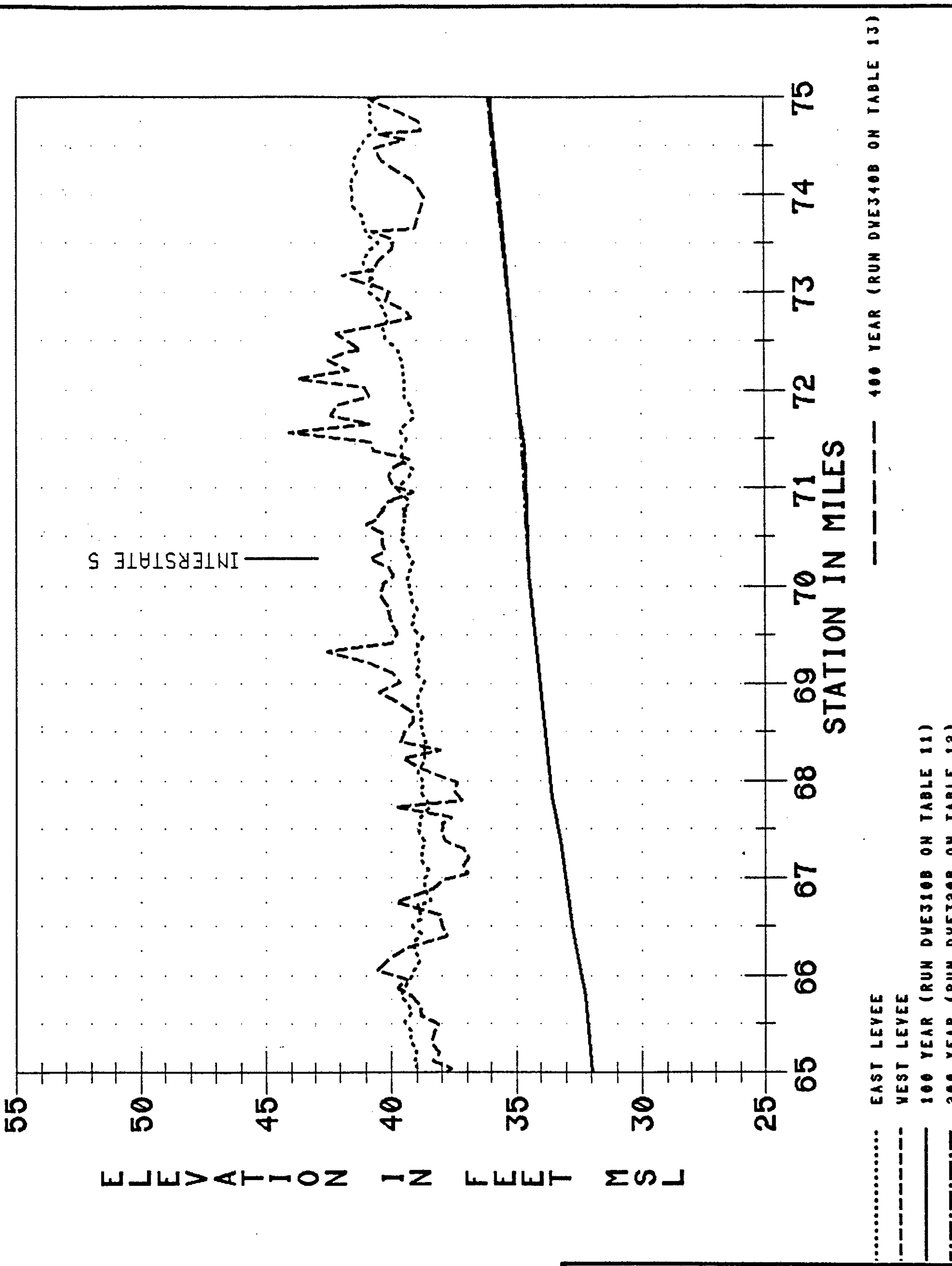
SACRAMENTO METRO INVESTIGATION

WATER SURFACE PROFILES
SACAMENTO RIVER

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.

Date: JUNE 1990



SACRAMENTO METRO INVESTIGATION

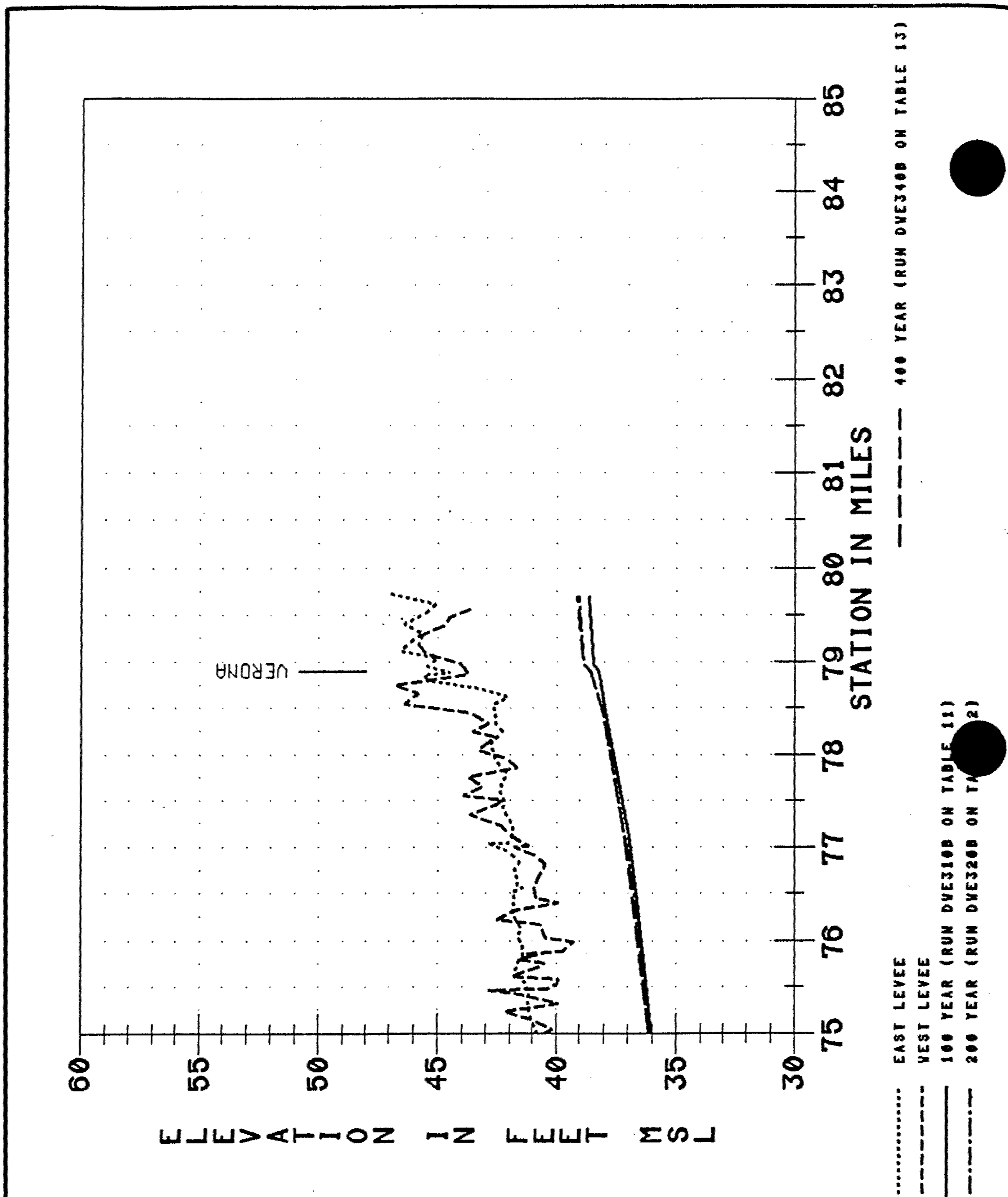
WATER SURFACE PROFILES
SACRAMENTO RIVER

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H.
Drawn: J.H.

Date: JUNE 1990

SHEET 3 OF 4 CHART 34



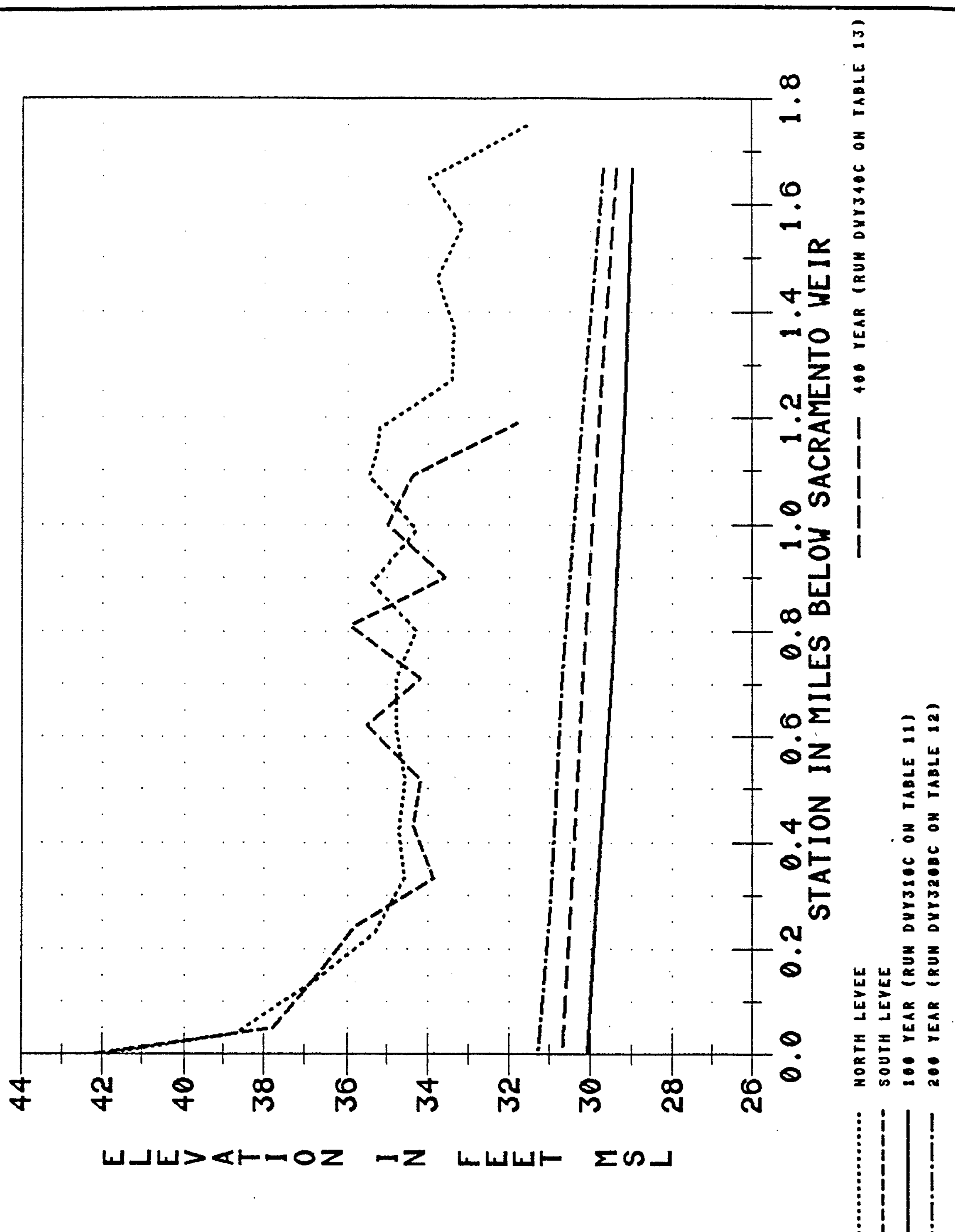
SACRAMENTO METRO INVESTIGATION

WATER SURFACE PROFILES SACRAMENTO RIVER

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.

Date: JUNE 1990



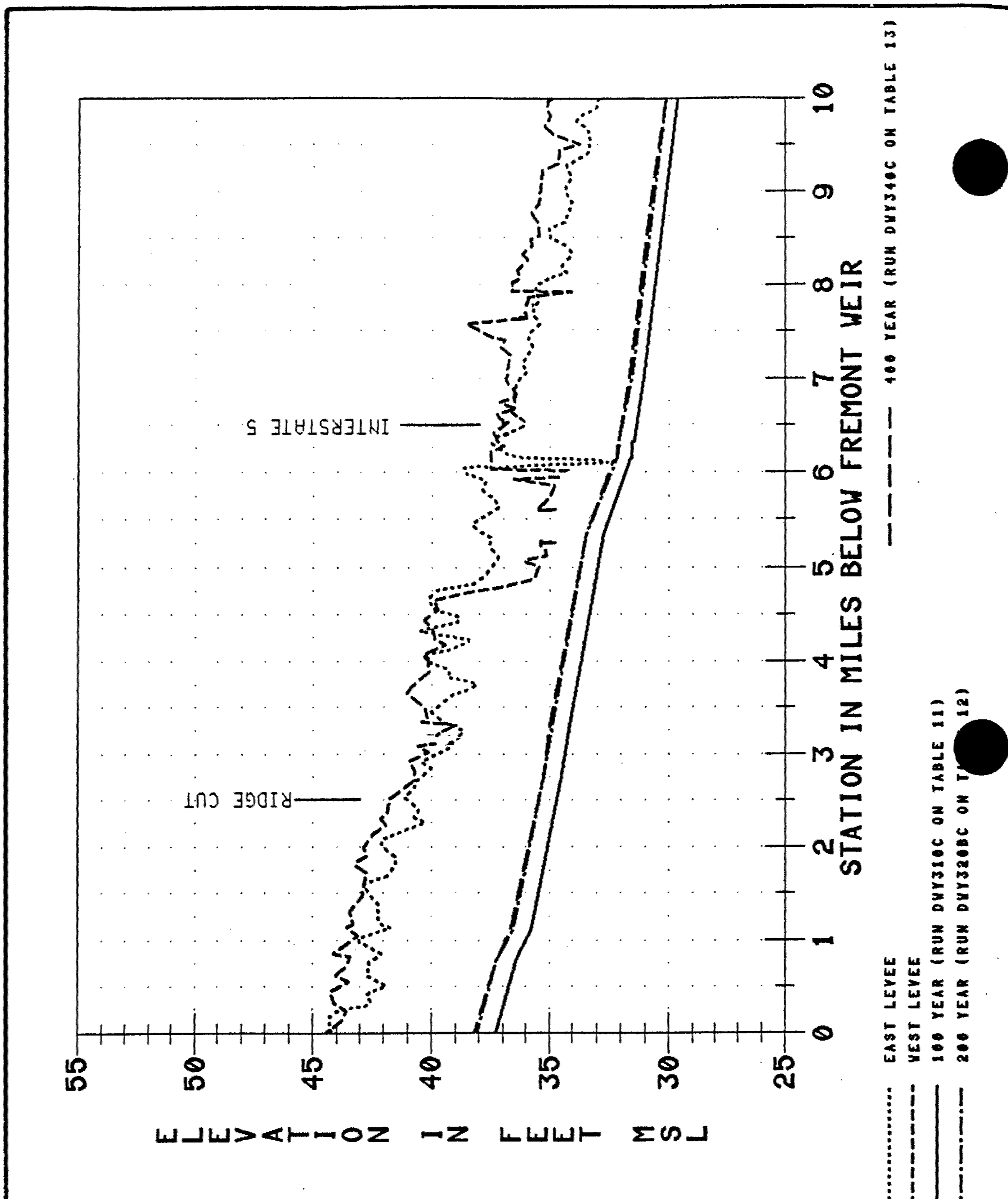
SACRAMENTO METRO INVESTIGATION

WATER SURFACE PROFILES
SACRAMENTO BYPASS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

CHART 35



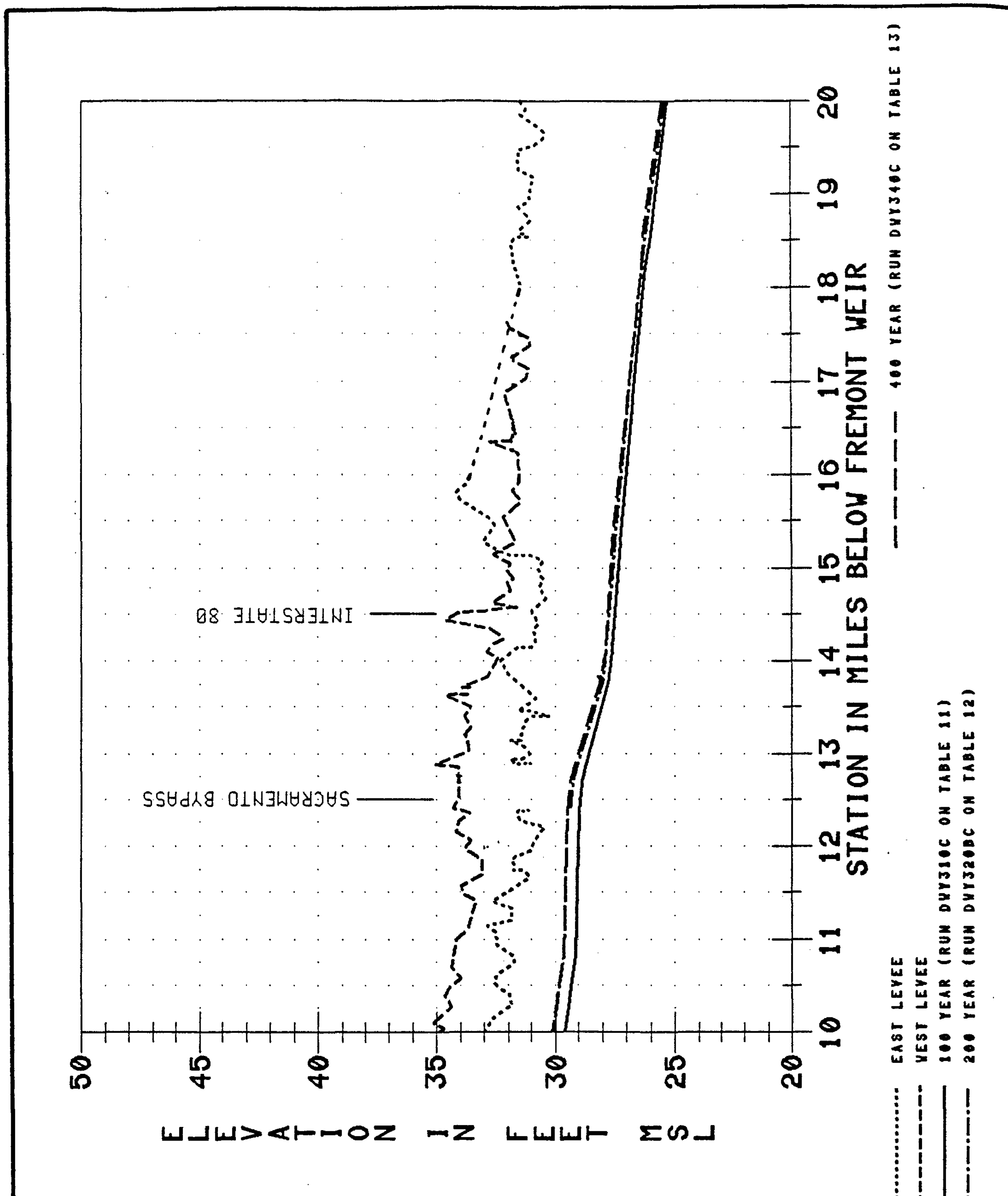
SACRAMENTO METRO INVESTIGATION

WATER SURFACE PROFILES
YOLO BYPASS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

SHEET 1 OF 3 CHART 36



SACRAMENTO METRO INVESTIGATION

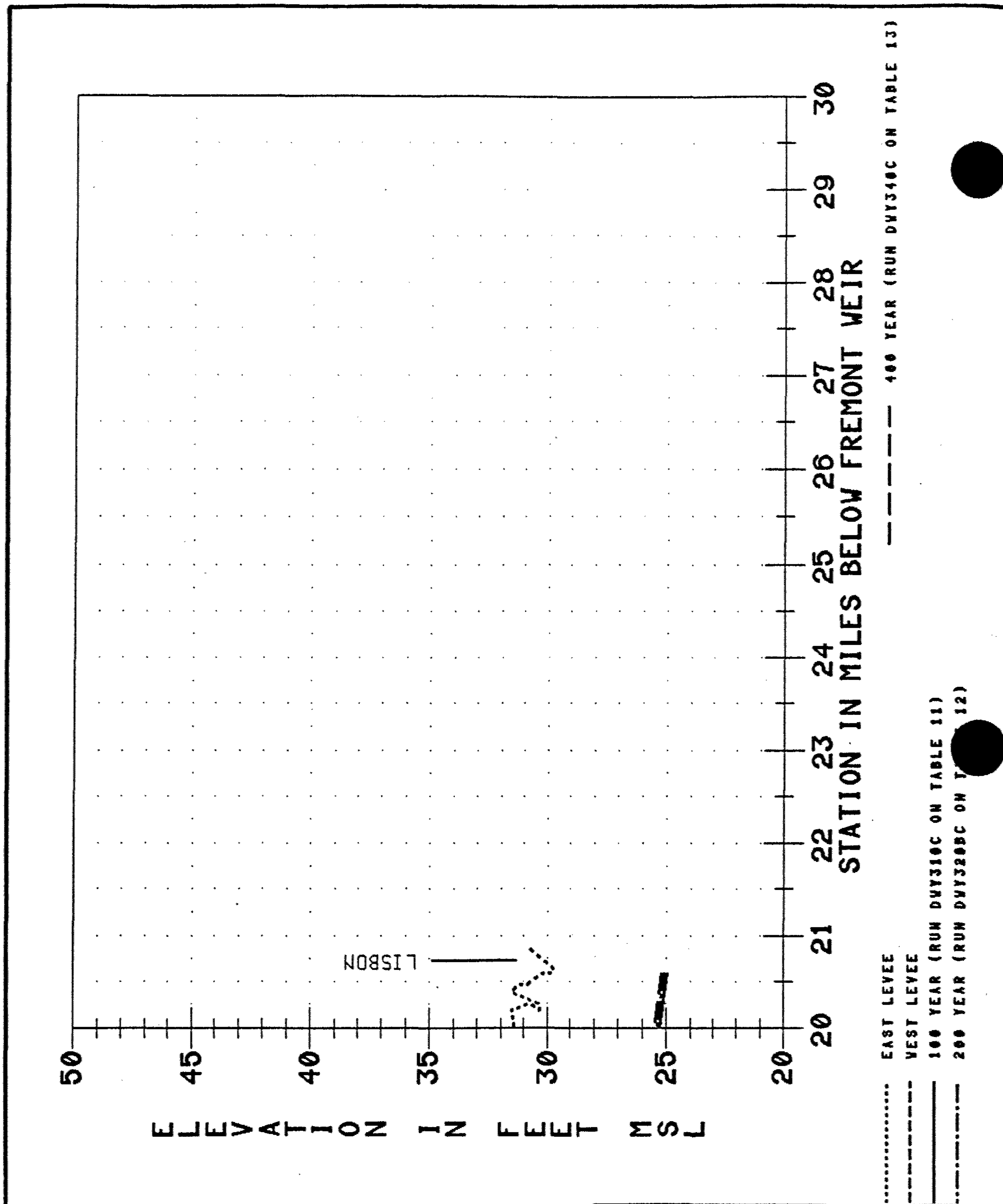
WATER SURFACE PROFILES
YOLO BYPASS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.

Date: JUNE 1990

SHEET 2 OF 3 CHART 36

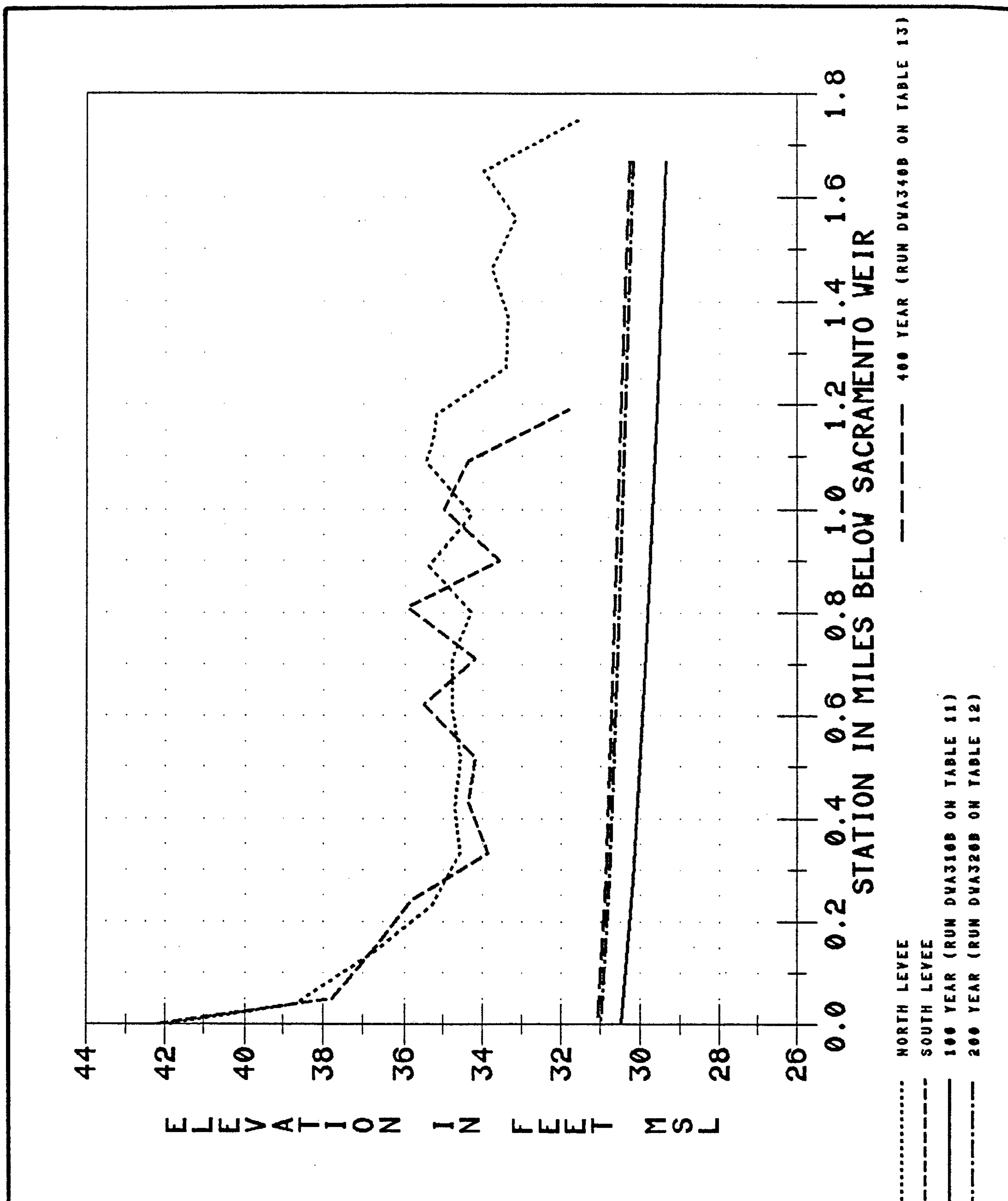


SACRAMENTO METRO INVESTIGATION

WATER SURFACE PROFILES
YOLO BYPASS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H. Drawn: J.H.	Date: JUNE 1990



SACRAMENTO METRO INVESTIGATION

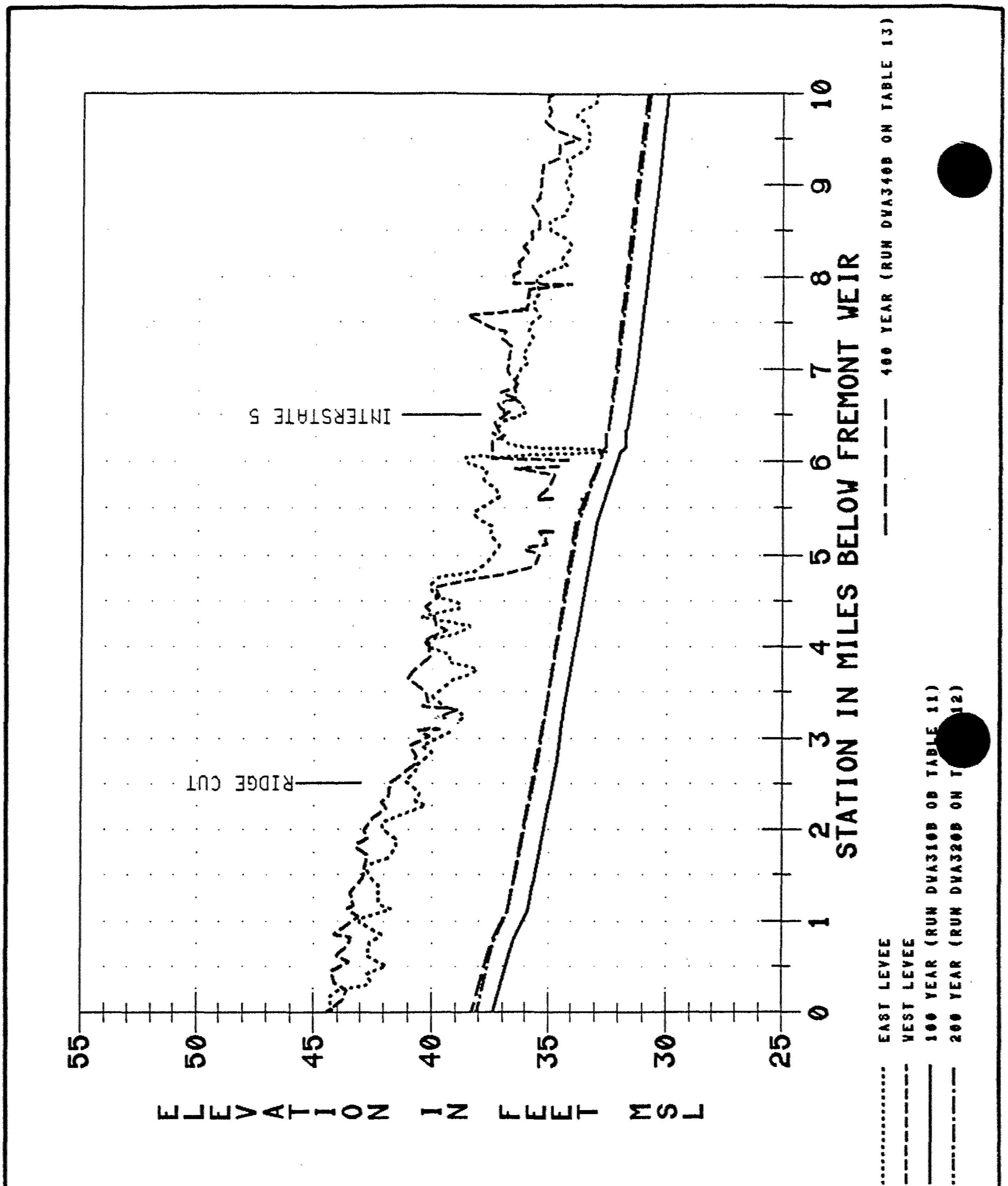
WATER SURFACE PROFILES SACRAMENTO BYPASS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.

Date: JUNE 1990

CHART 37



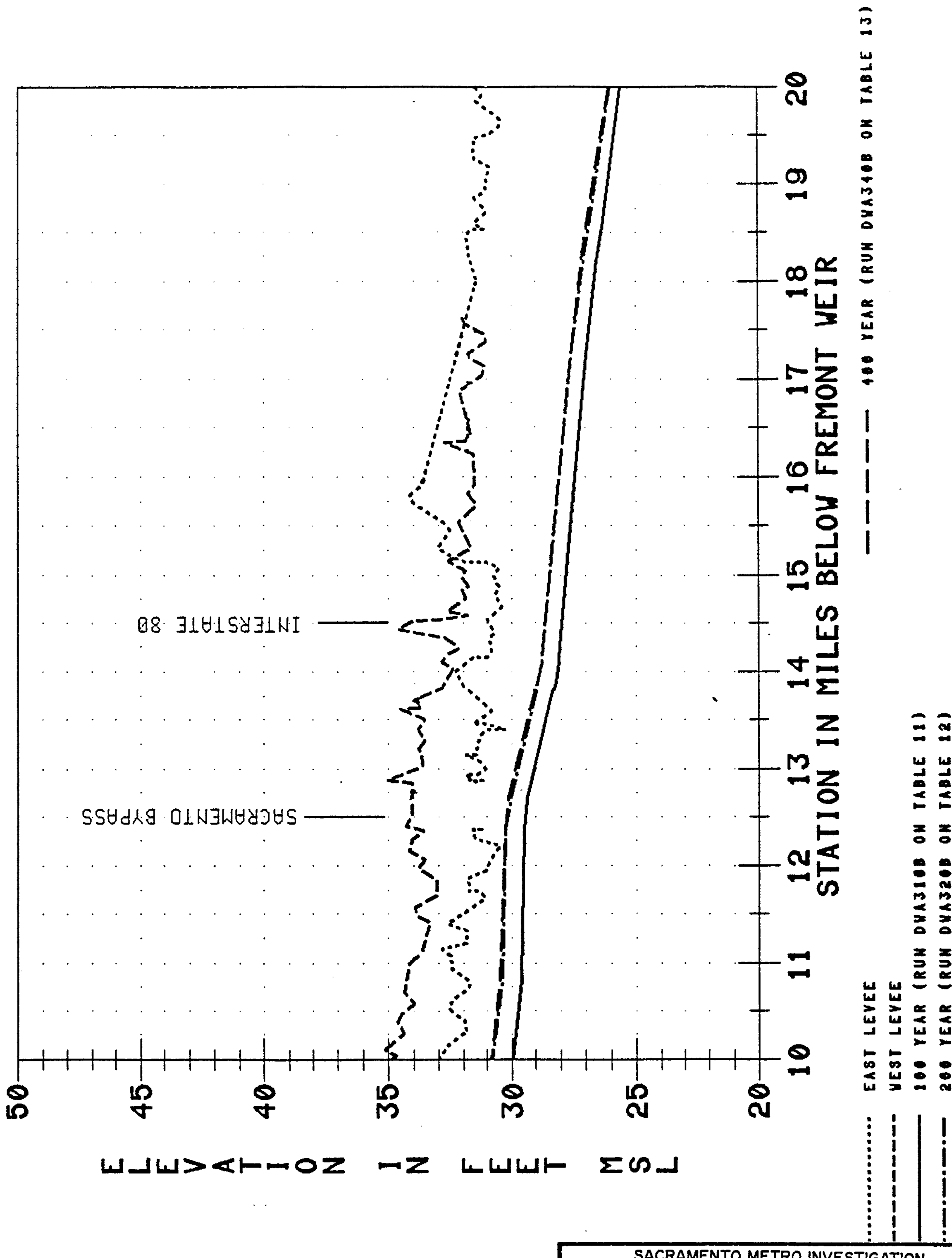
SACRAMENTO METRO INVESTIGATION

WATER SURFACE PROFILES
YOLO BYPASS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H. Drawn: J.H.	Date: JUNE 1990

SHEET 1 OF 3 CHART 38



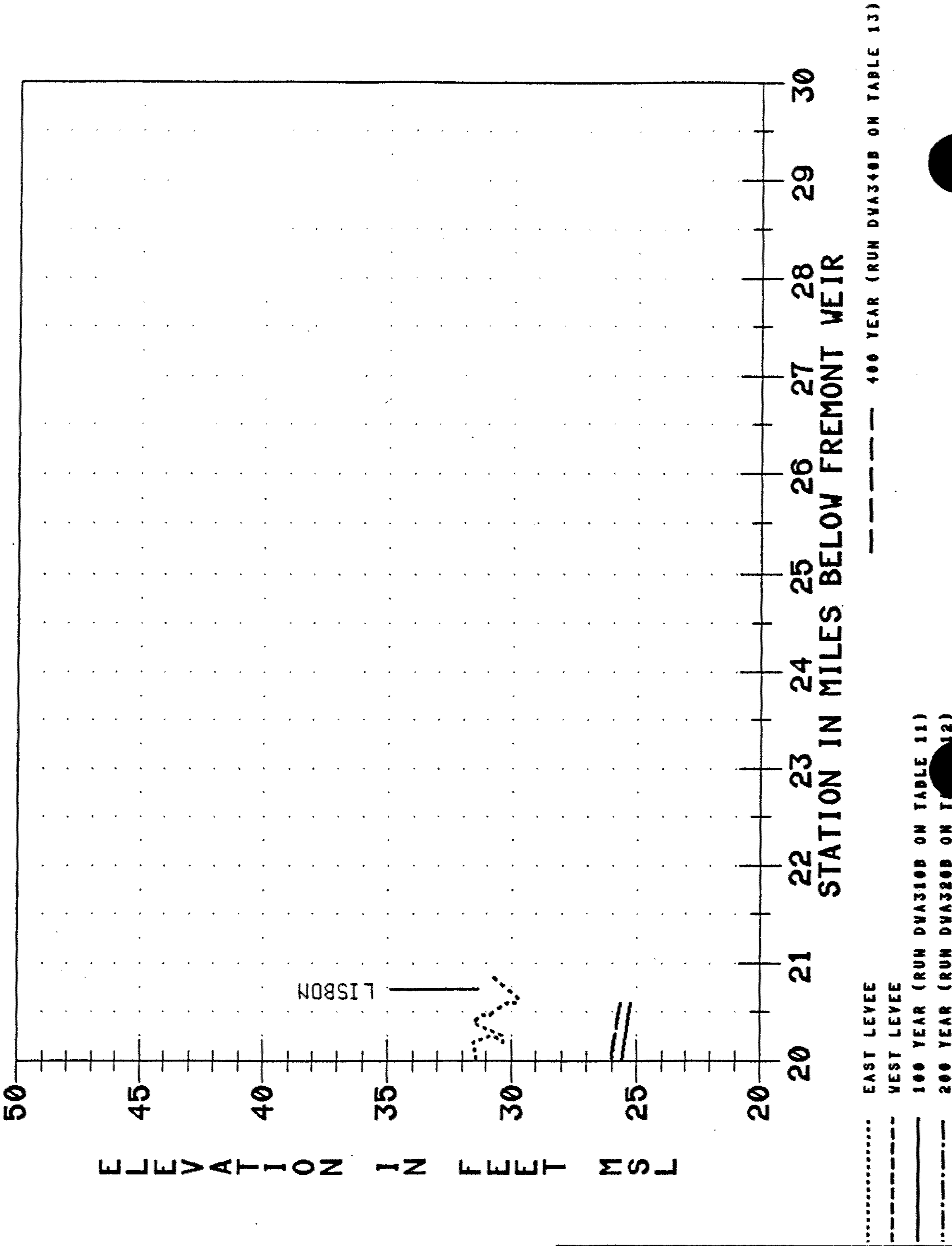
SACRAMENTO METRO INVESTIGATION

WATER SURFACE PROFILES
YOLO BYPASS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

SHEET 2 OF 3 CHART 38



SACRAMENTO METRO INVESTIGATION

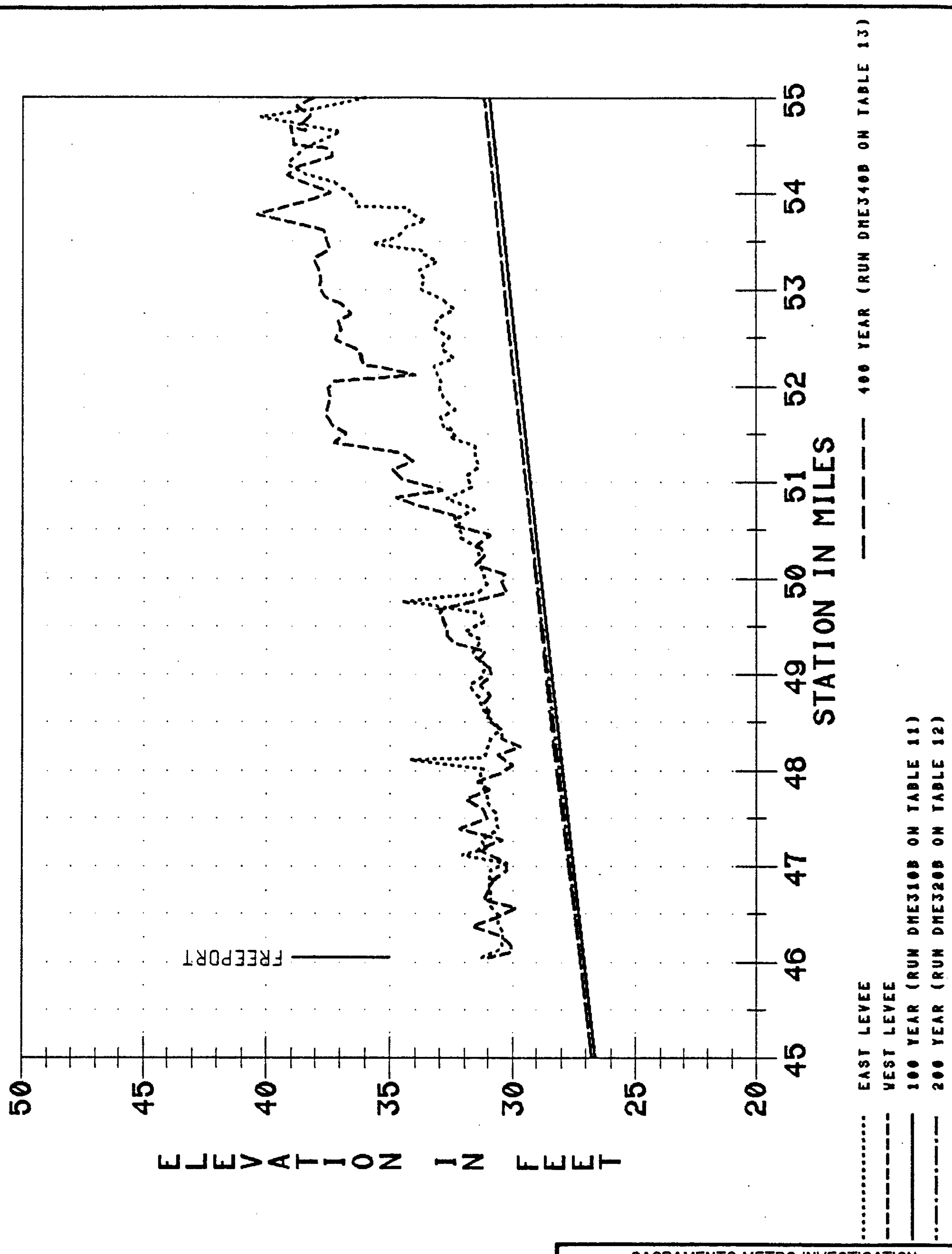
WATER SURFACE PROFILES
YOLO BYPASS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.

Date: JUNE 1990

SHEET 3 OF 3 CHART 38



SACRAMENTO METRO INVESTIGATION

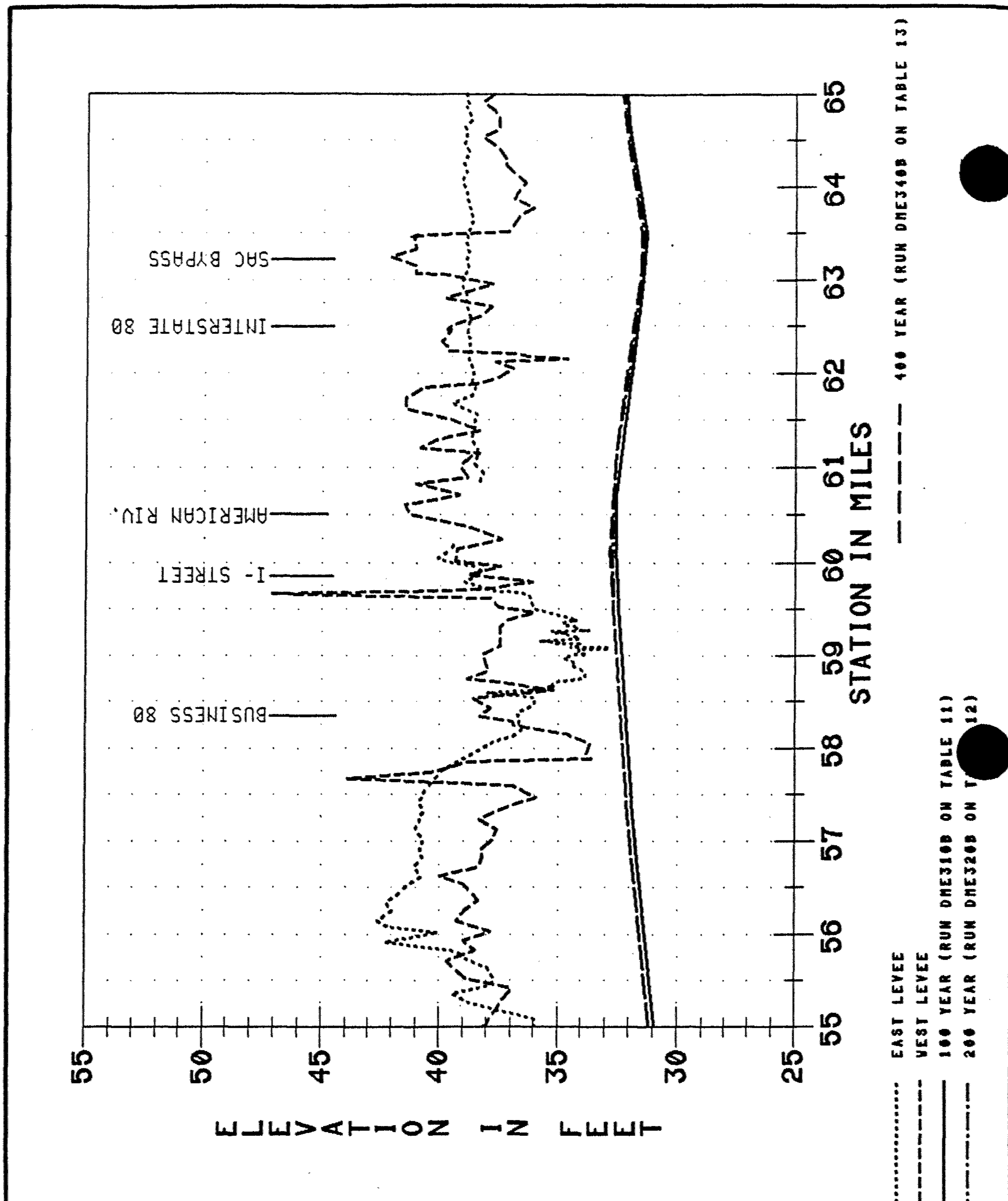
WATER SURFACE PROFILES
SACRAMENTO RIVER

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.

Date: JUNE 1990

SHEET I OF 4 CHART 39



SACRAMENTO METRO INVESTIGATION

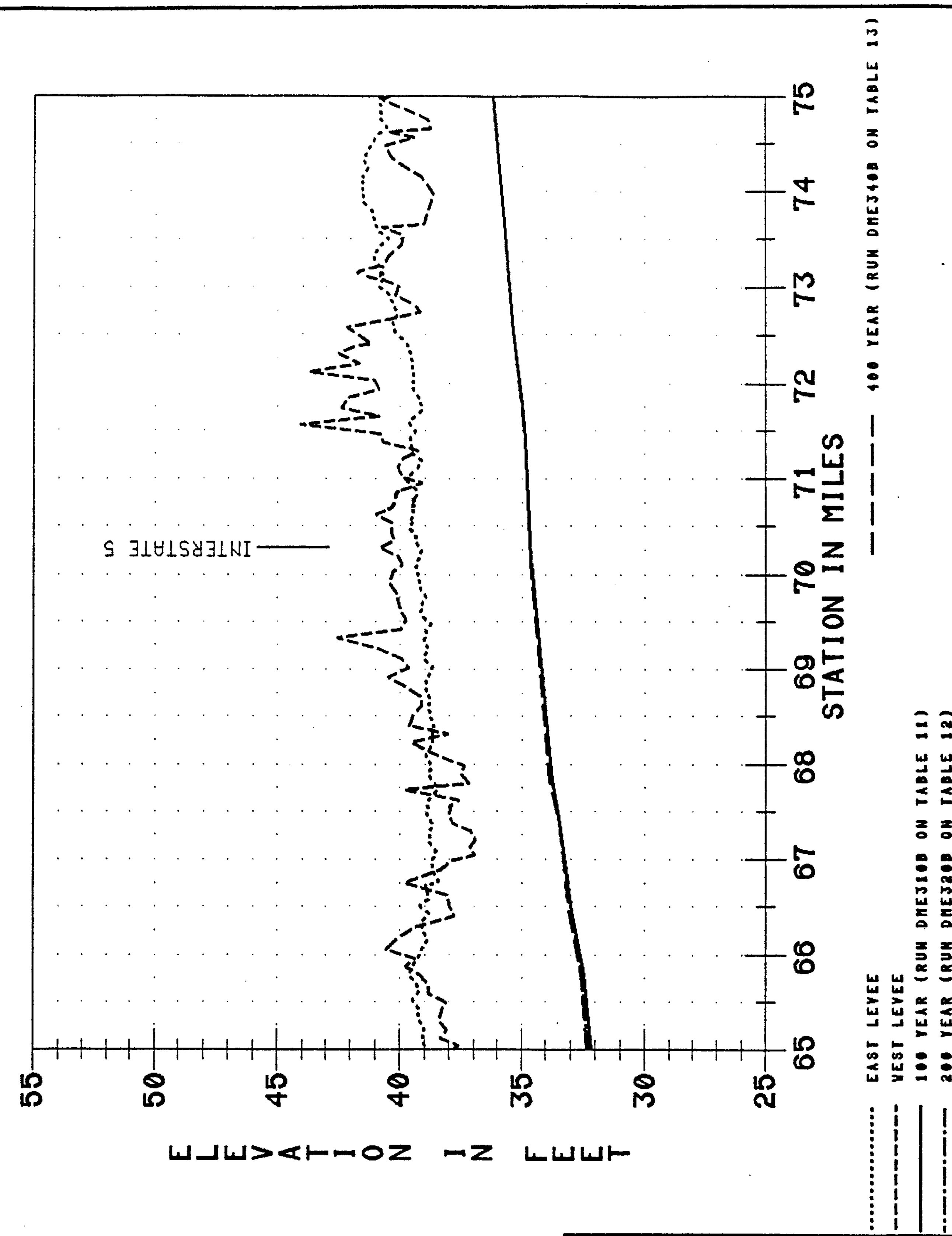
WATER SURFACE PROFILES
SACRAMENTO RIVER

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.

Date: JUNE 1990

SHEET 2 OF 4 CHART 39



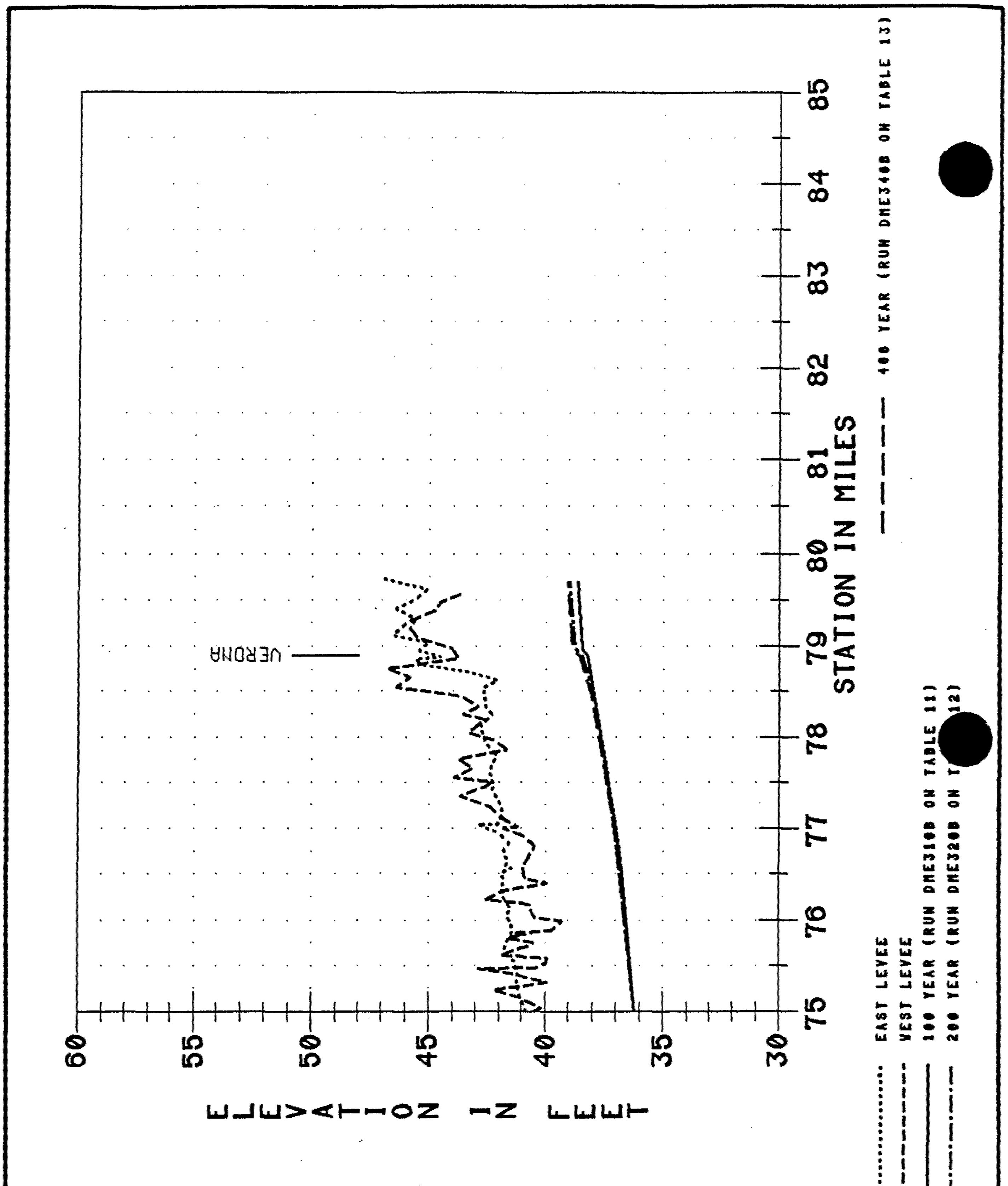
SACRAMENTO METRO INVESTIGATION

WATER SURFACE PROFILES
SACRAMENTO RIVER

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

SHEET 3 OF 4 CHART 39



SACRAMENTO METRO INVESTIGATION

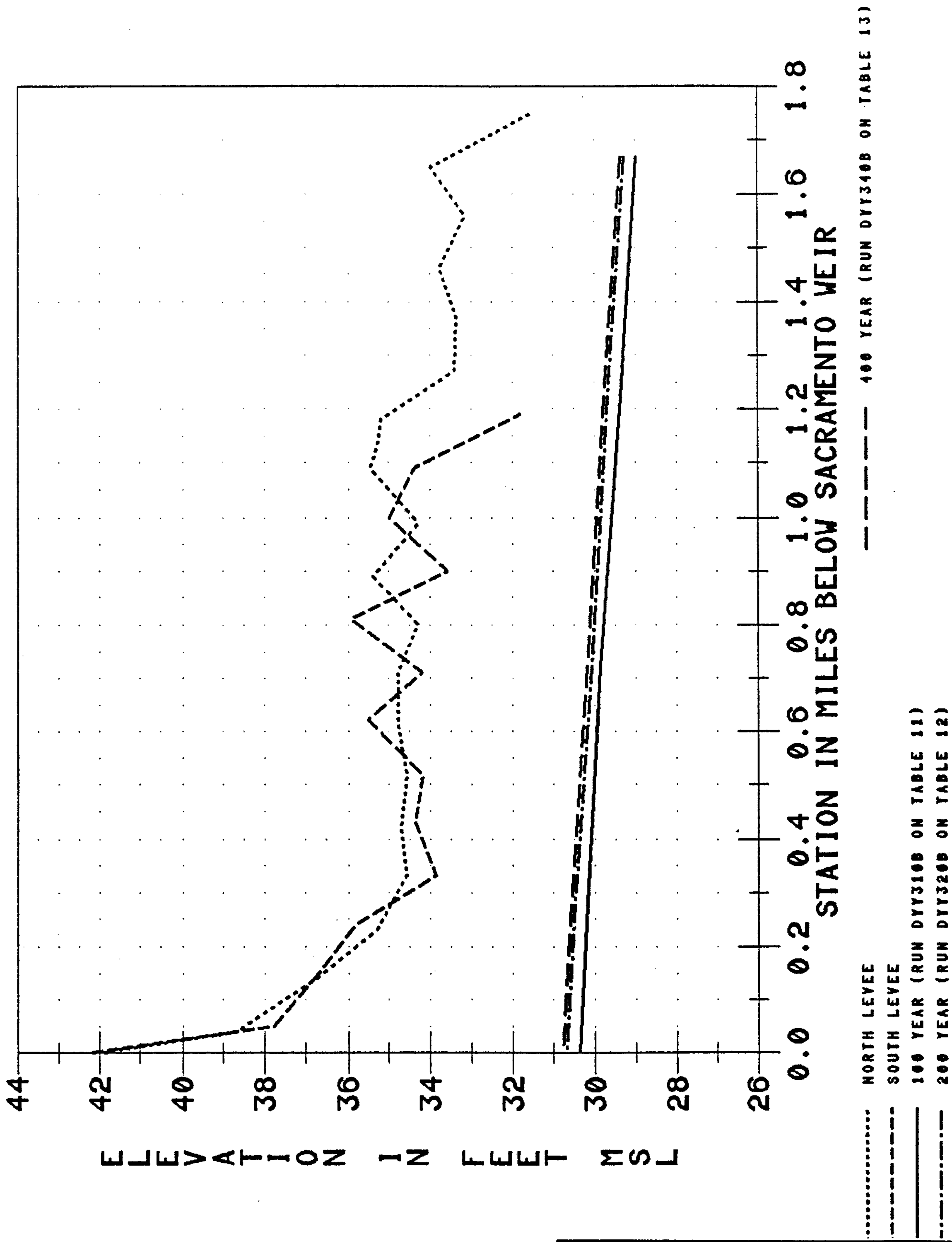
WATER SURFACE PROFILES
SACRAMENTO RIVER

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.

Date: JUNE 1990

SHEET 4 OF 4 CHART 39



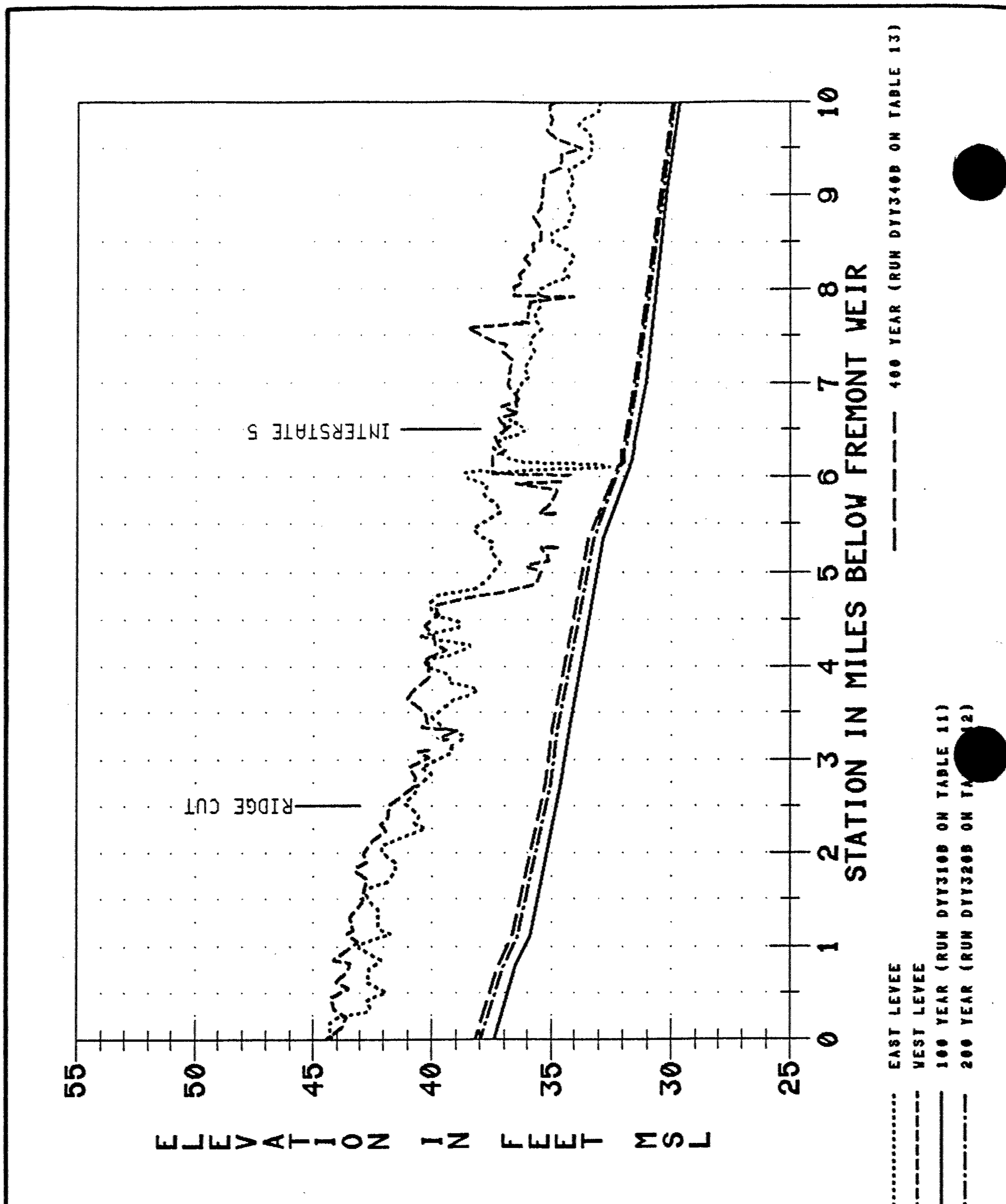
SACRAMENTO METRO INVESTIGATION

WATER SURFACE PROFILES
SACRAMENTO BYPASS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H. Drawn: J.H.	Date: JUNE 1990

CHART 40



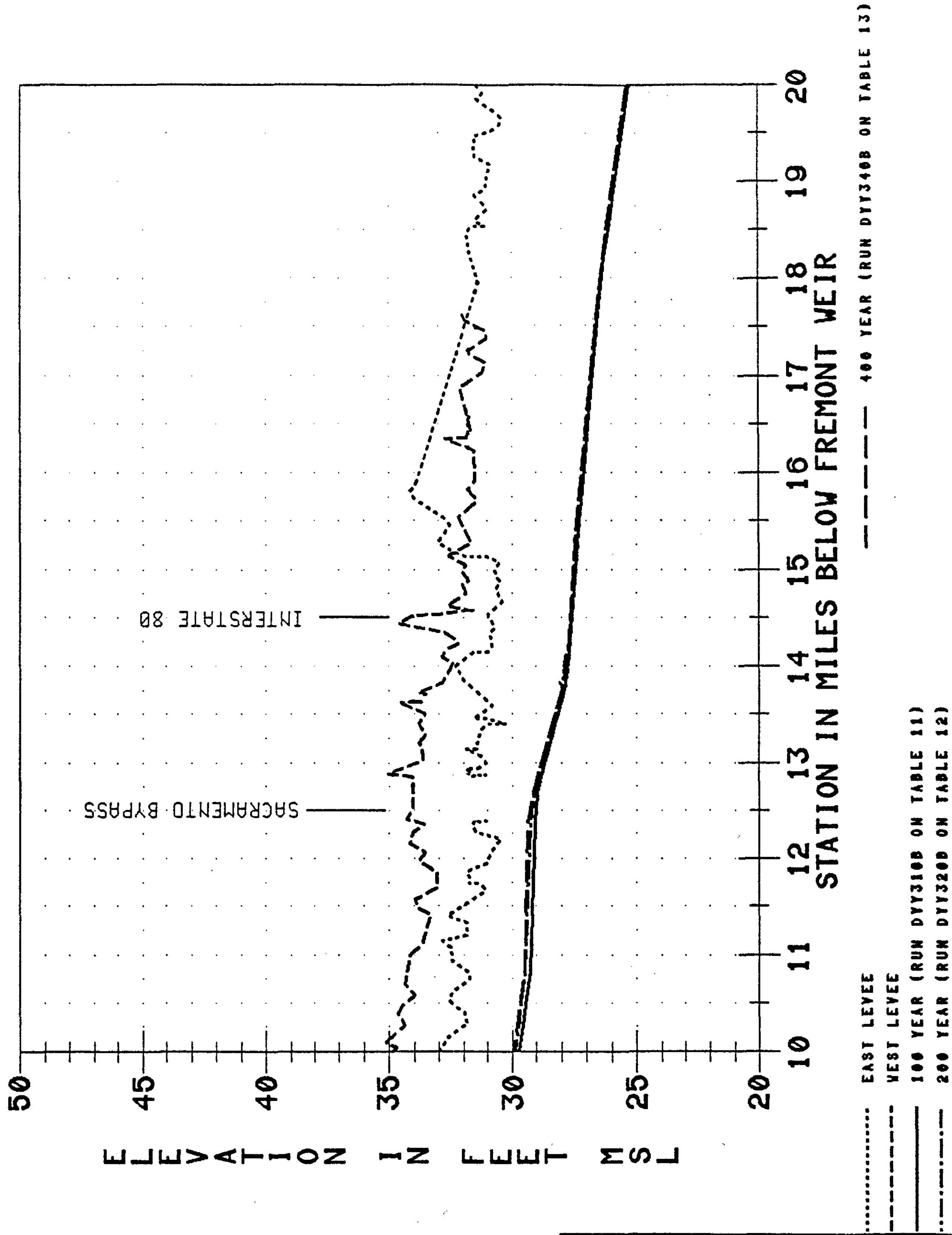
SACRAMENTO METRO INVESTIGATION

WATER SURFACE PROFILES
YOLO BYPASS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

SHEET 1 OF 3 CHART 41



SACRAMENTO METRO INVESTIGATION

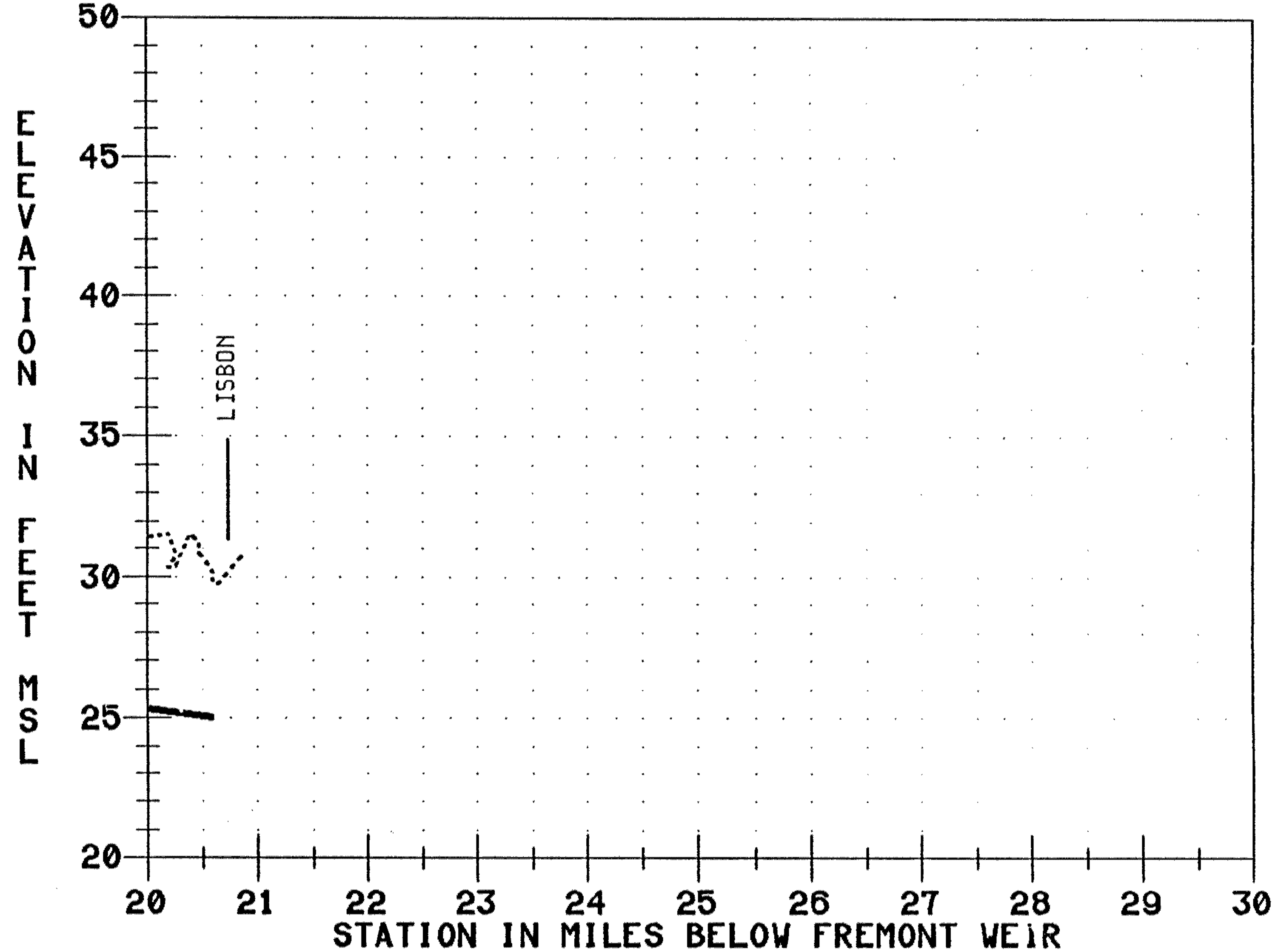
WATER SURFACE PROFILES
YOLO BYPASS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H.
Drawn: J.H.

Date: JUNE 1990

SHEET 2 OF 3 CHART 41



EAST LEVEE
WEST LEVEE
100 YEAR (RUN DYY310B ON TABLE 11)
200 YEAR (RUN DYY320B ON T 12)
400 YEAR (RUN DYY340B ON TABLE 13)

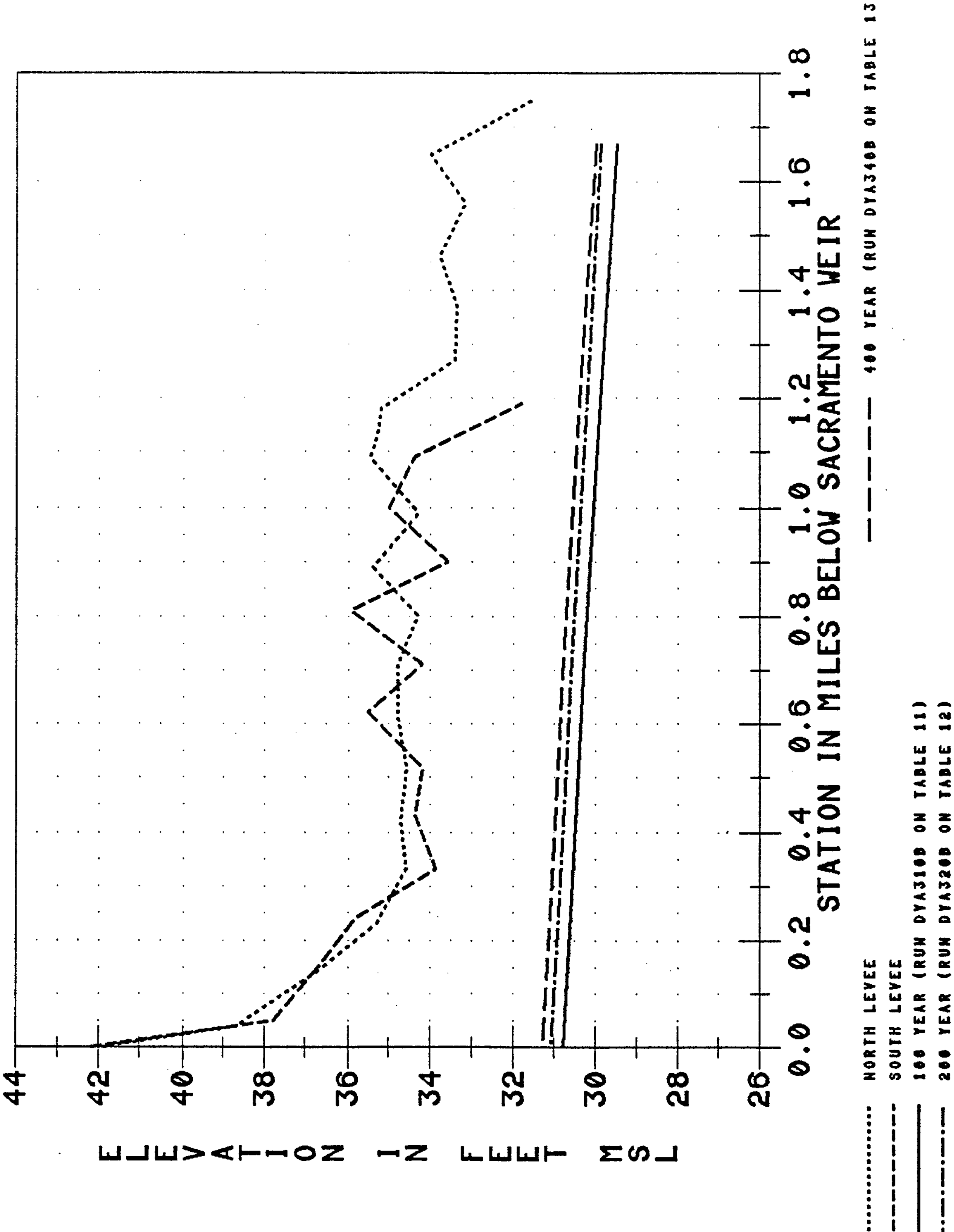
SACRAMENTO METRO INVESTIGATION

WATER SURFACE PROFILES
YOLO BYPASS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

SHEET 3 OF 3 CHART 41



SACRAMENTO METRO INVESTIGATION

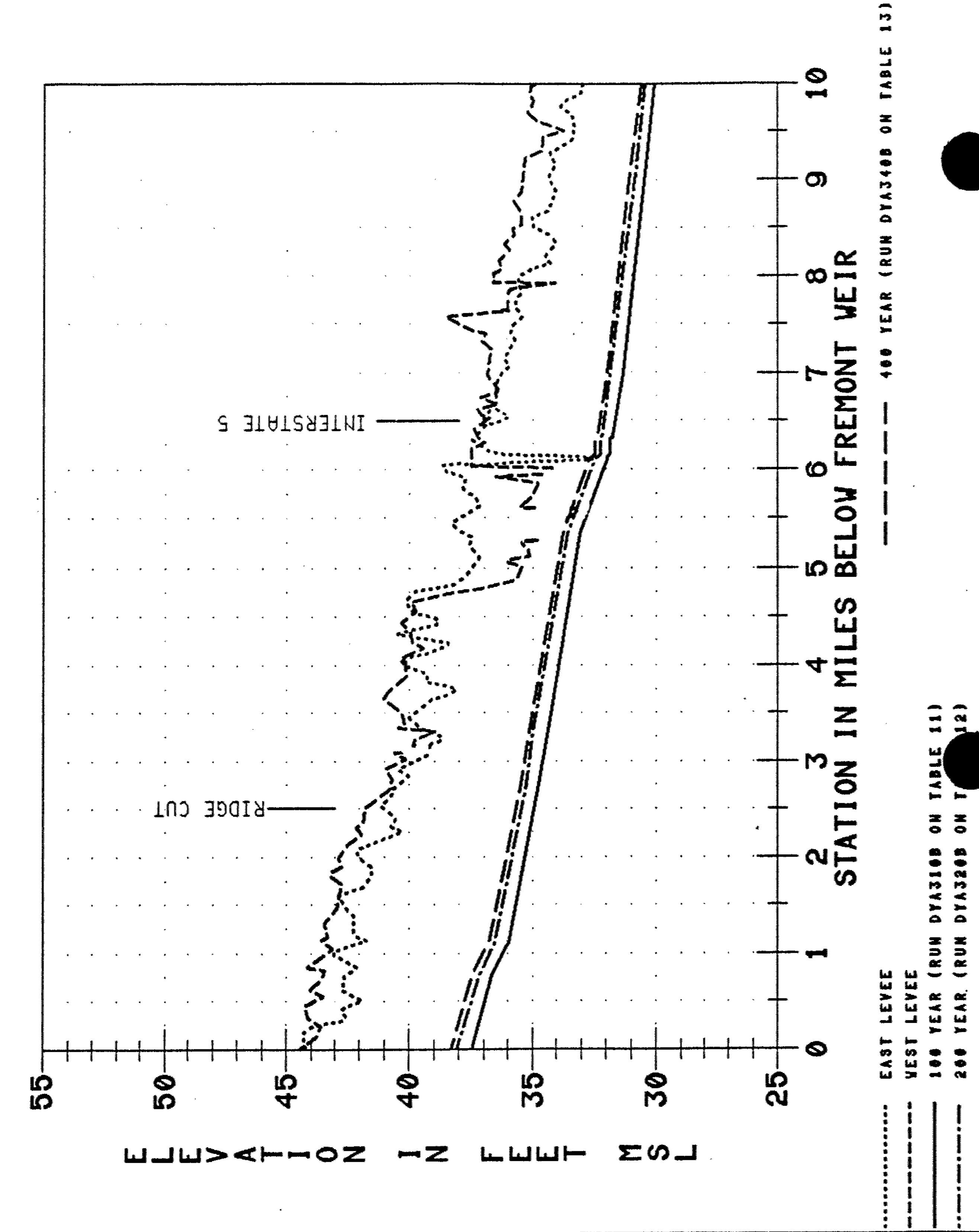
WATER SURFACE PROFILES SACRAMENTO BYPASS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.

Date: JUNE 1990

CHART 42



SACRAMENTO METRO INVESTIGATION

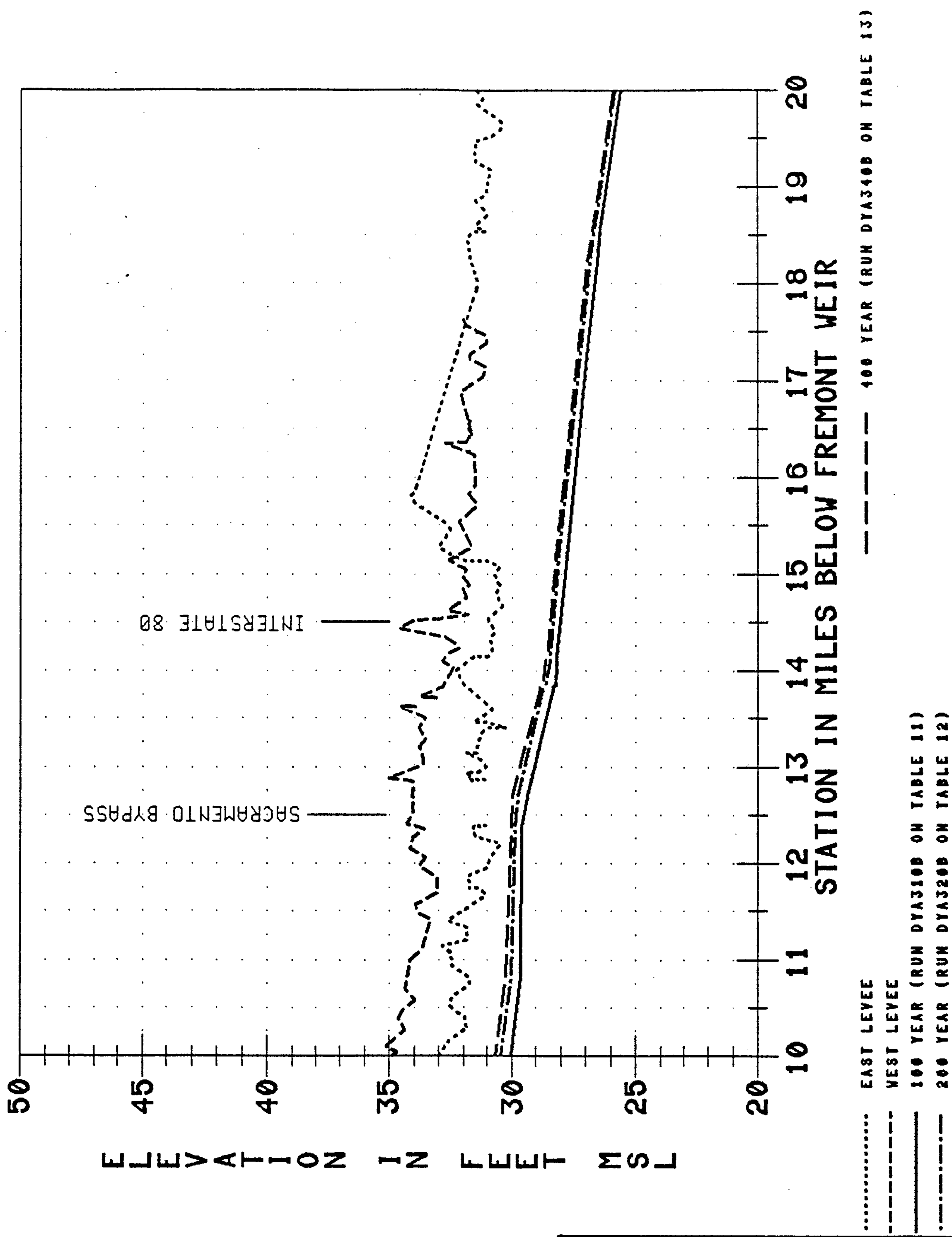
WATER SURFACE PROFILES
YOLO BYPASS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.

Date: JUNE 1990

SHEET I OF 3 CHART 43



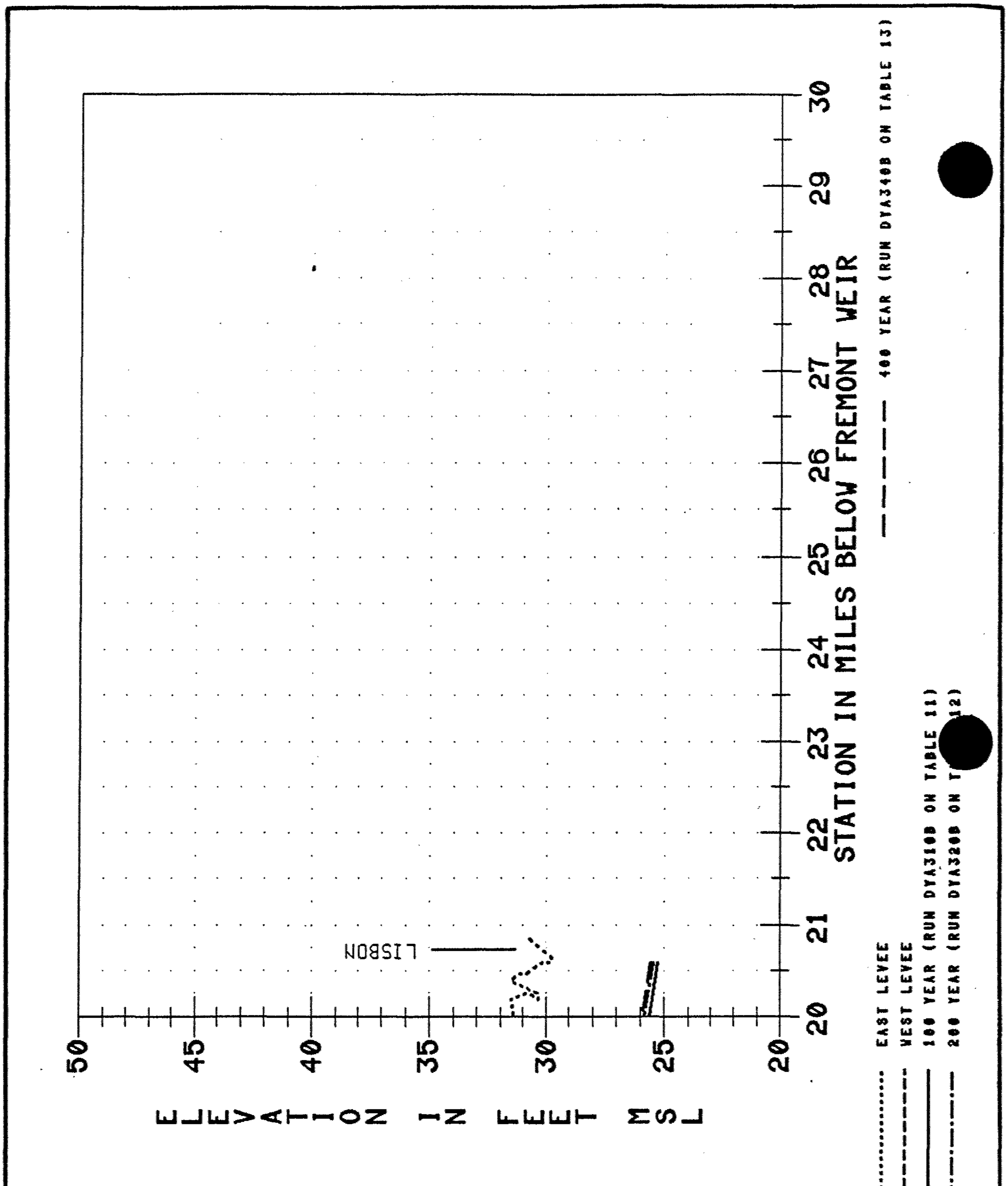
SACRAMENTO METRO INVESTIGATION

WATER SURFACE PROFILES
YOLO BYPASS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

SHEET 2 OF 3 CHART 43



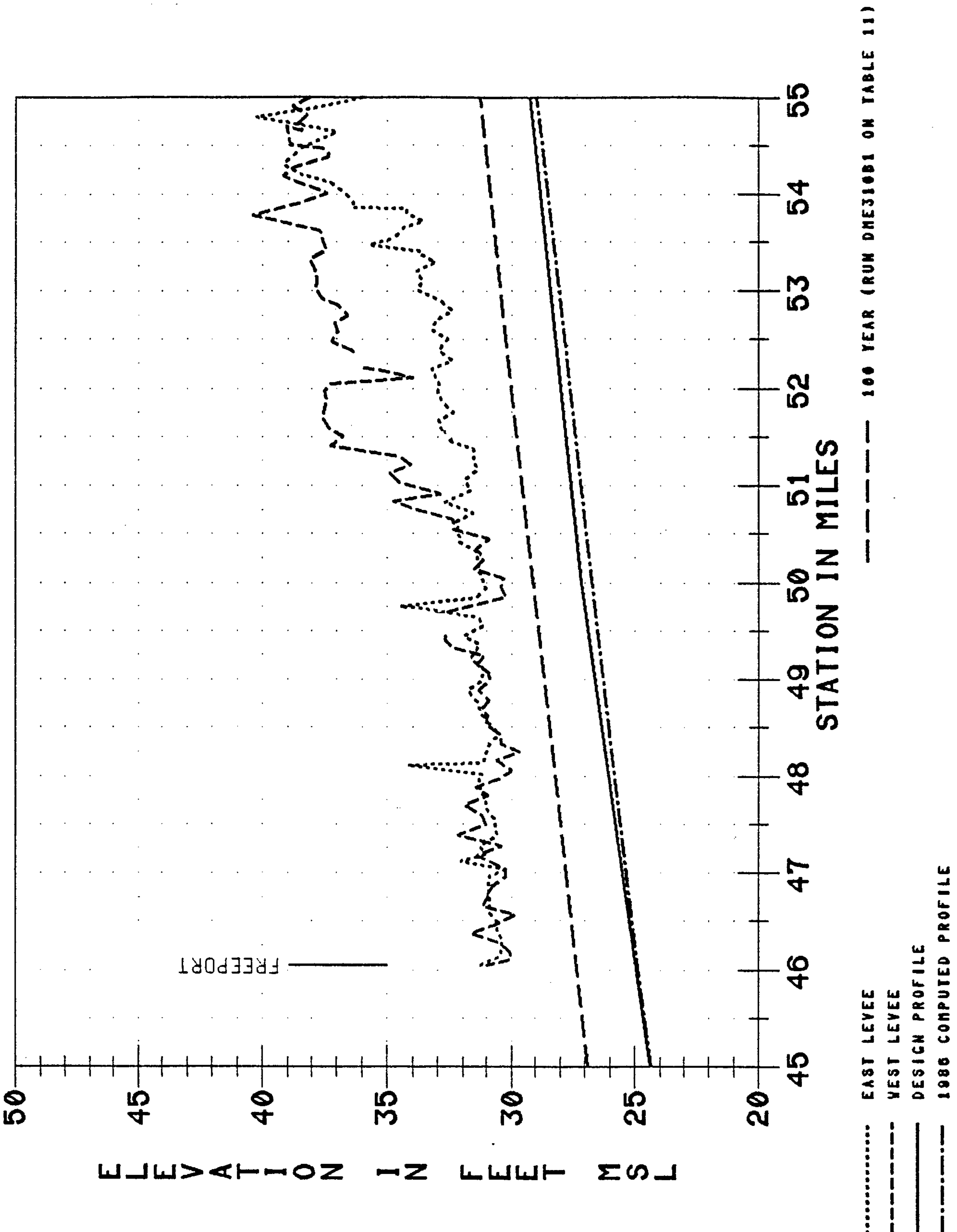
SACRAMENTO METRO INVESTIGATION

WATER SURFACE PROFILES
YOLO BYPASS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

SHEET 3 OF 3 CHART 43



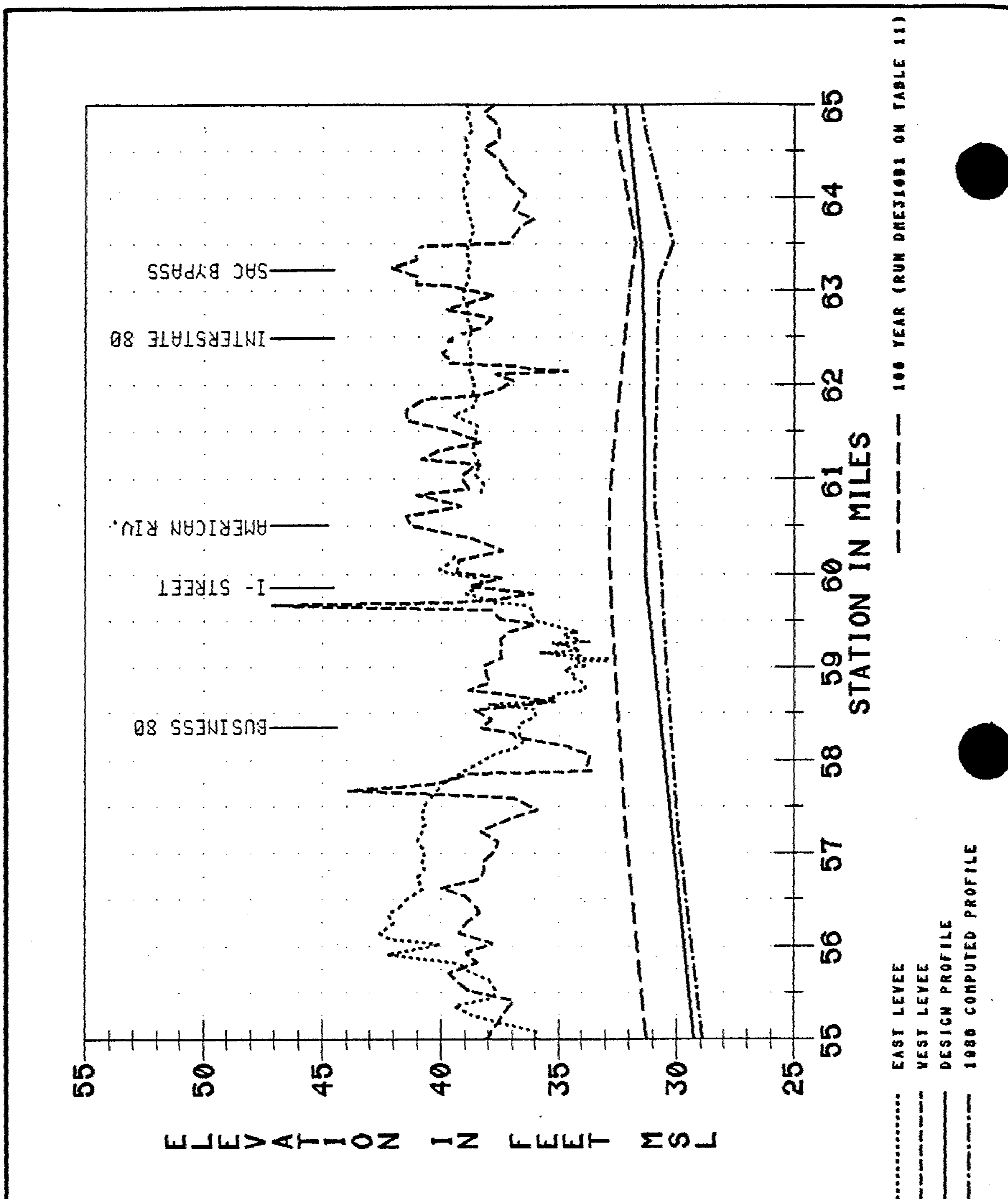
SACRAMENTO METRO INVESTIGATION

DESIGN PROFILE COMPARISON
SACRAMENTO RIVER

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

SHEET I OF 4 CHART 44

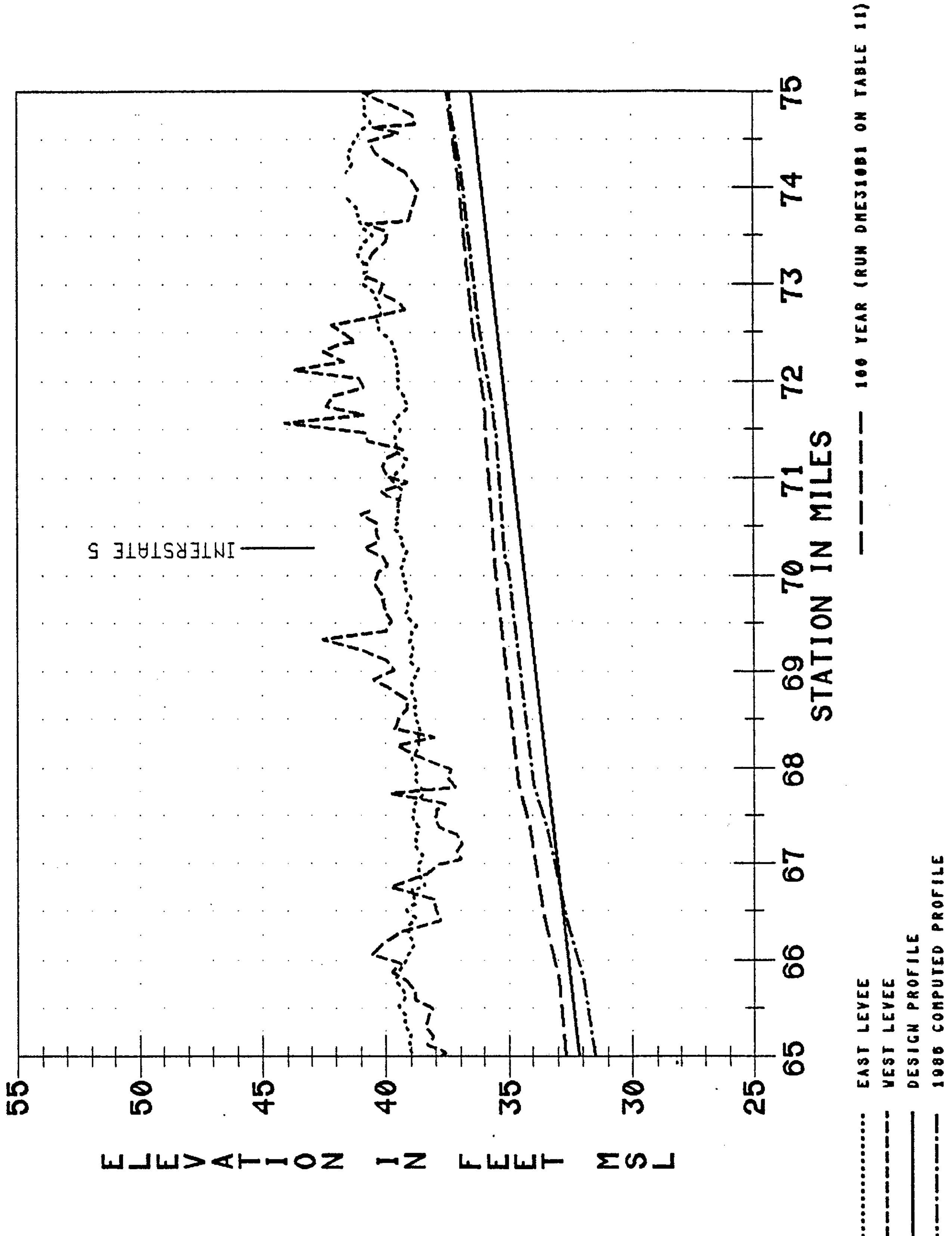


SACRAMENTO METRO INVESTIGATION

DESIGN PROFILE COMPARISON
SACRAMENTO RIVER

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

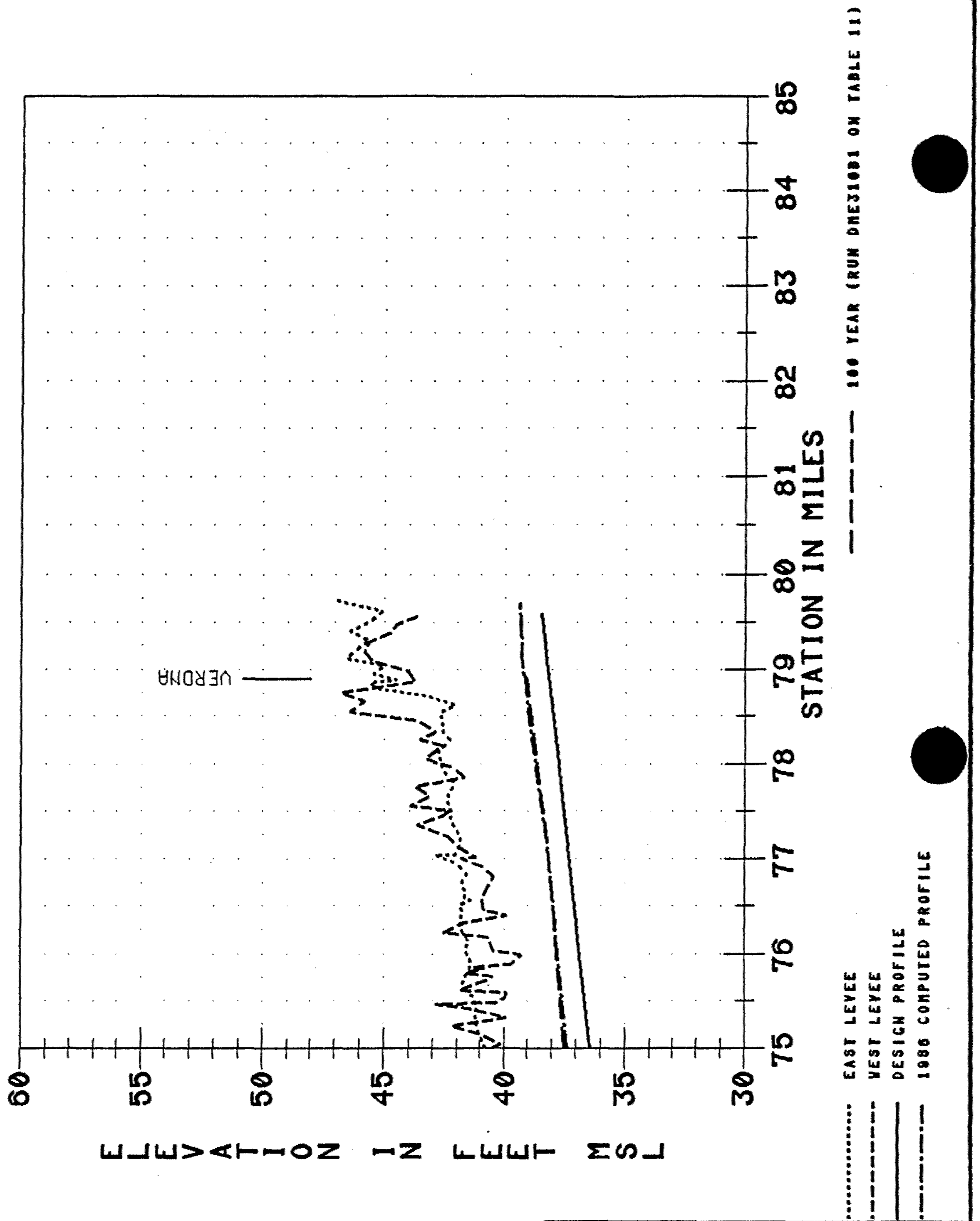


SACRAMENTO METRO INVESTIGATION

DESIGN PROFILE COMPARISON SACRAMENTO RIVER

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990



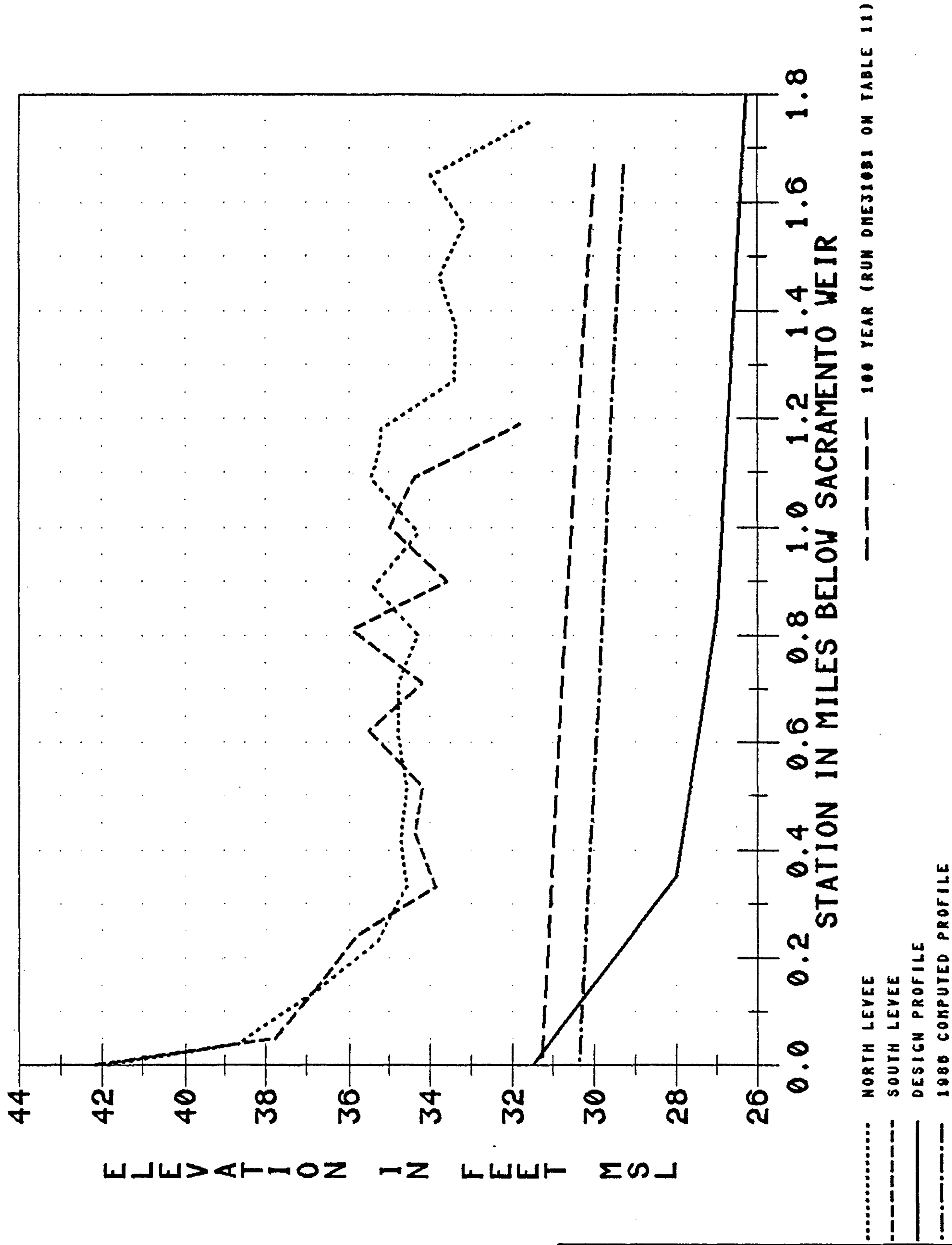
SACRAMENTO METRO INVESTIGATION

DESIGN PROFILE COMPARISON SACRAMENTO RIVER

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H.
Drawn: J.H.

Date: JUNE 1990



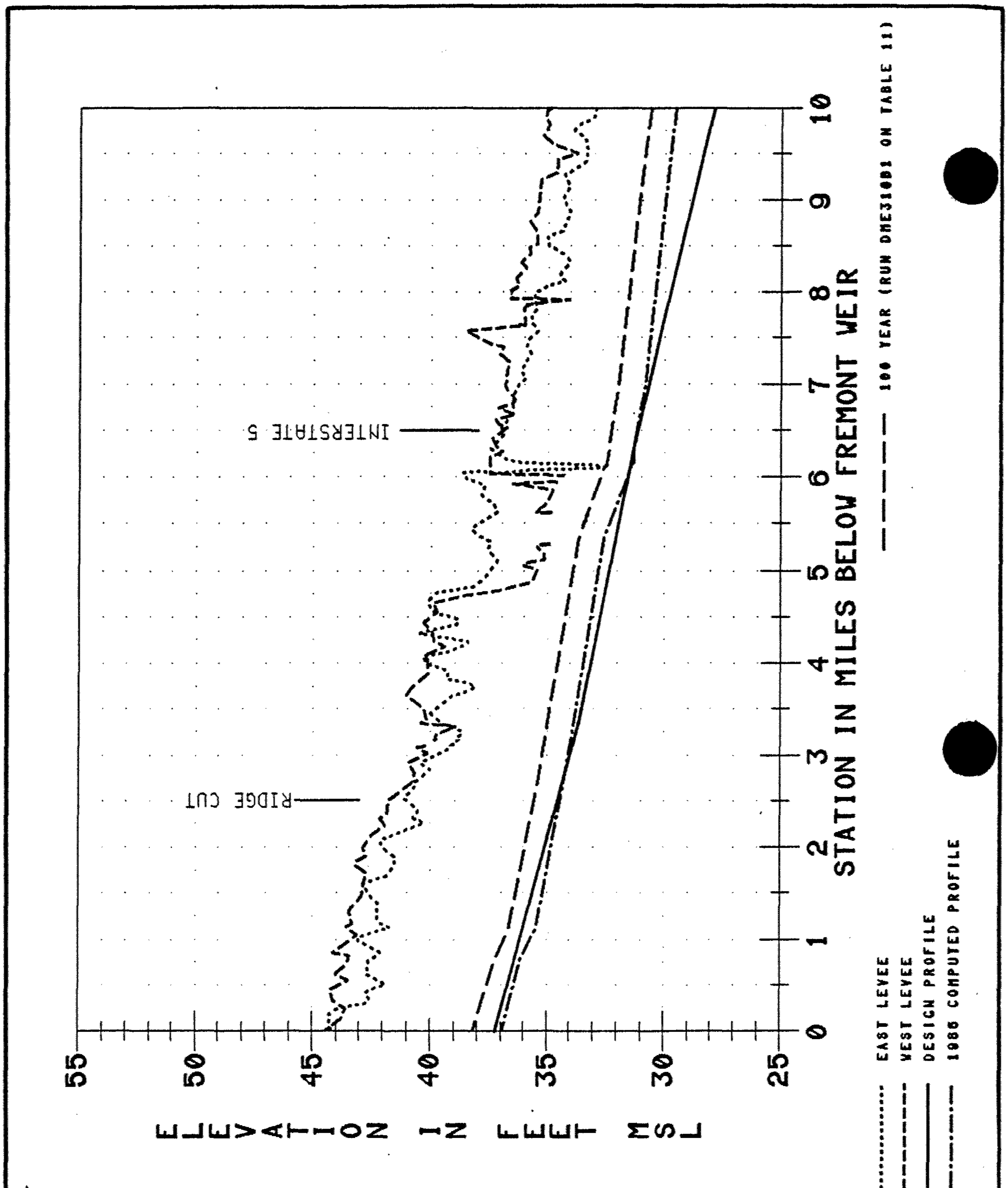
SACRAMENTO METRO INVESTIGATION

DESIGN PROFILE COMPARISON SACRAMENTO BYPASS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H. Date: JUNE 1990

Drawn: J.H.



SACRAMENTO METRO INVESTIGATION

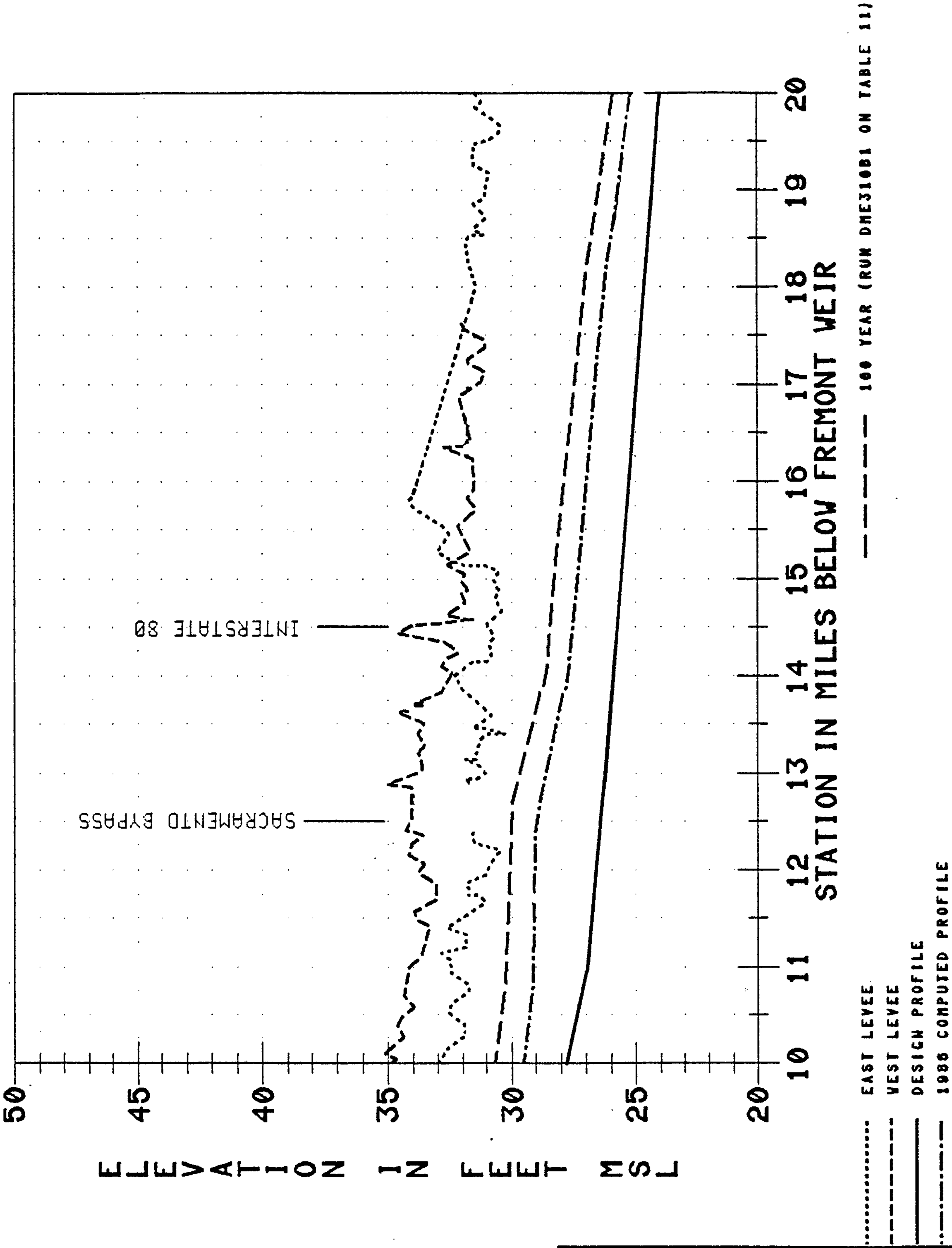
DESIGN PROFILE COMPARISON
YOLO BYPASS

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.

Date: JUNE 1990

SHEET I OF 3 CHART 46



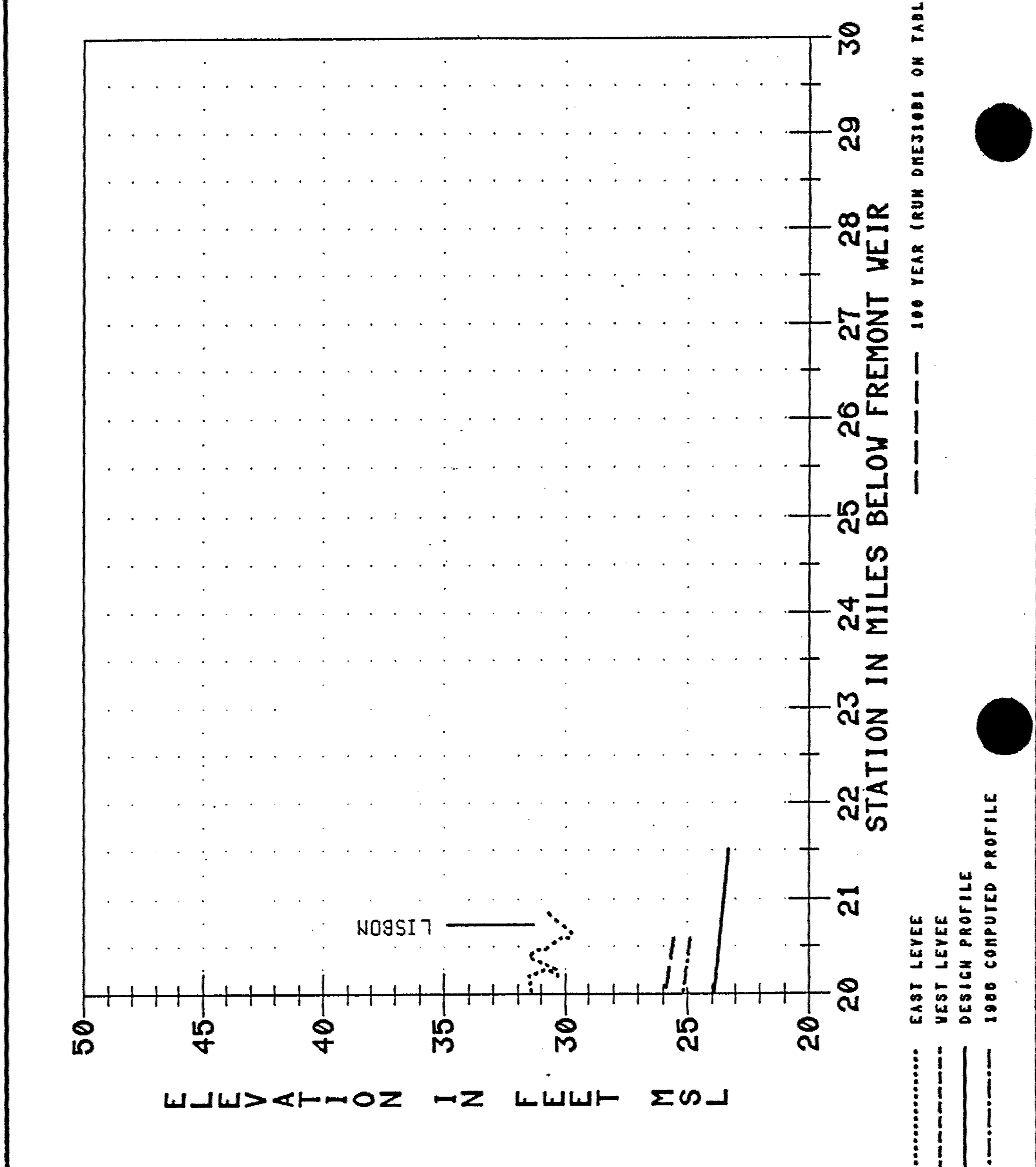
SACRAMENTO METRO INVESTIGATION

DESIGN PROFILE COMPARISON
YOLO BYPASS

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

SHEET 2 OF 3 CHART 46



SACRAMENTO METRO INVESTIGATION

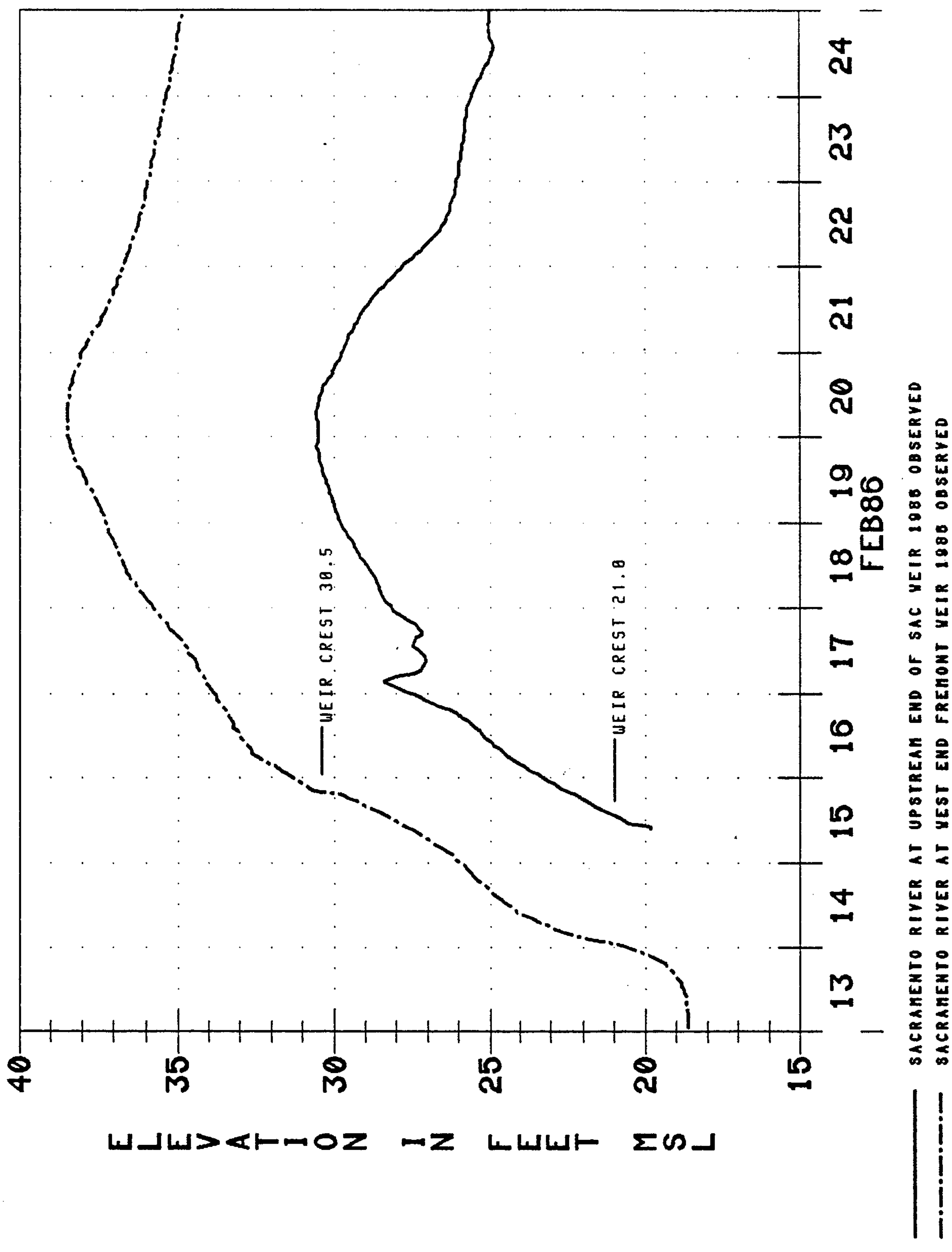
DESIGN PROFILE COMPARISON
YOLO BYPASS

CORPS OF ENGINEERS. SACRAMENTO. CALIF...A

Prepared: J.H.
Drawn: J.H.

Date: JUNE 1990

SHEET 3 OF 3 CHART 46



SACRAMENTO METRO INVESTIGATION

WEIR SPILL COMPARISON
SAC WEIR & FREMONT WEIR

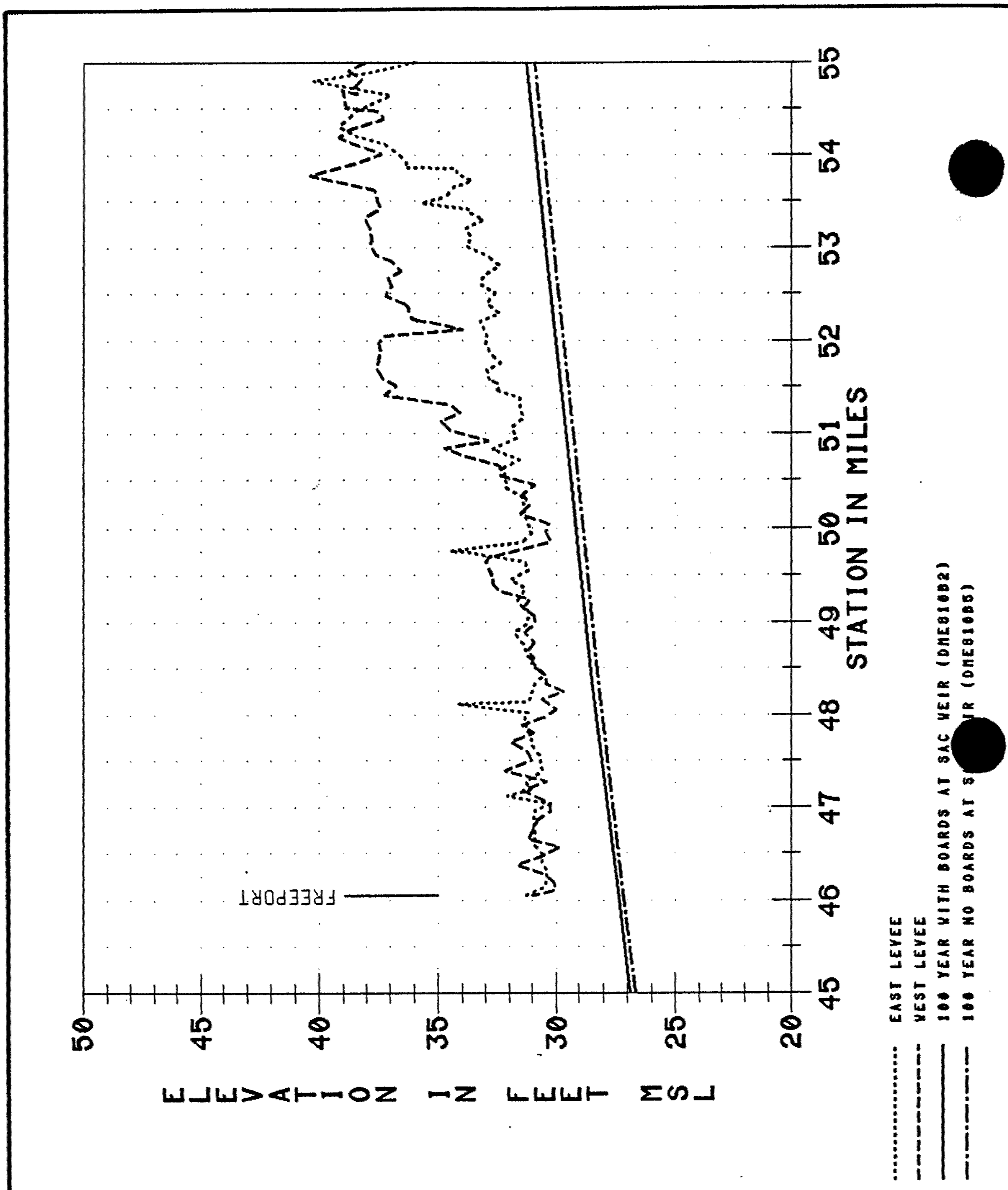
SAC WEIR SENSITIVITY

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.

Date: JUNE 1990

CHART 47



SACRAMENTO METRO INVESTIGATION

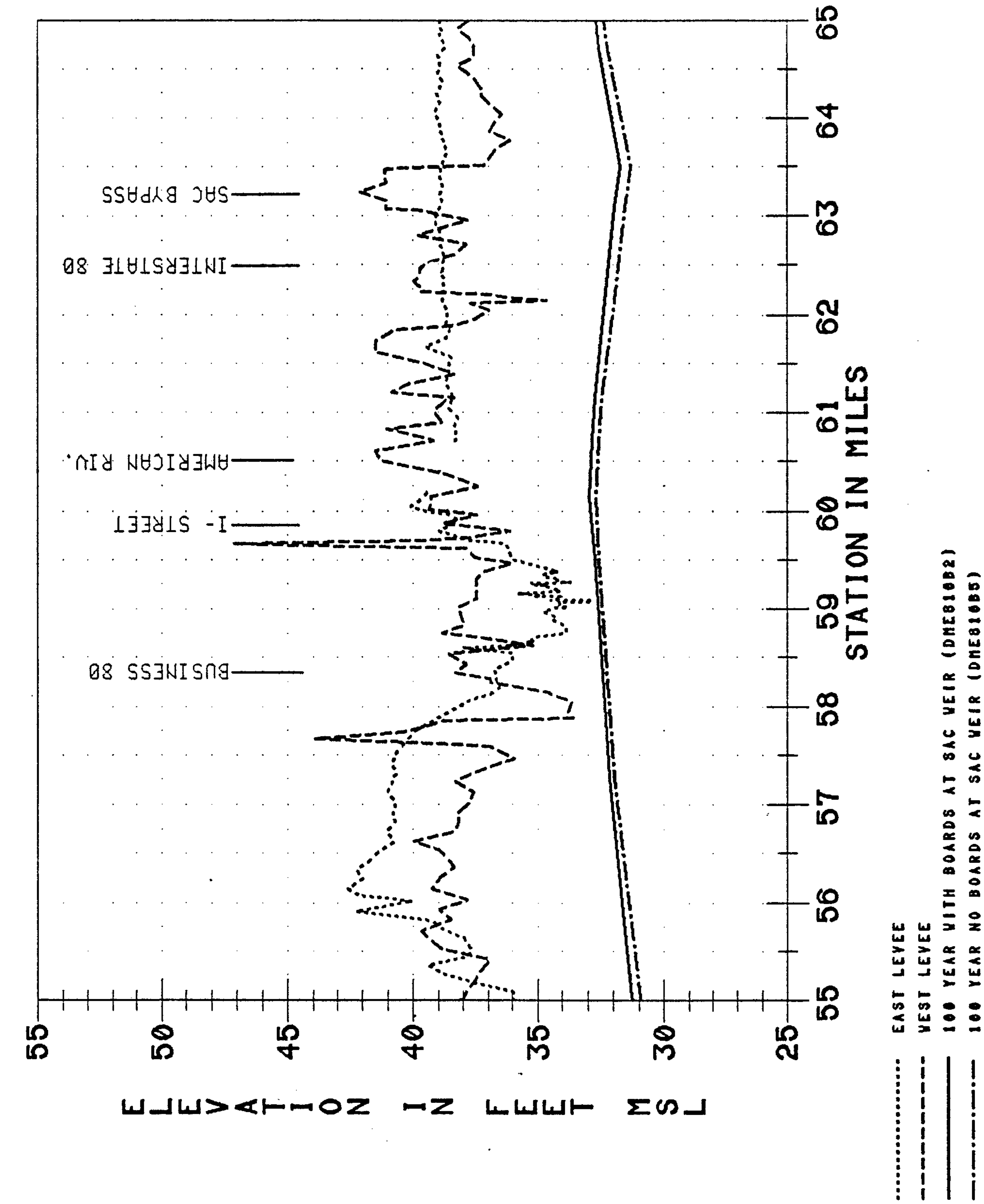
WATER SURFACE PROFILES SACRAMENTO RIVER

SAC WEIR SENSITIVITY

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

SHEET 1 OF 4 CHART 48



SACRAMENTO METRO INVESTIGATION

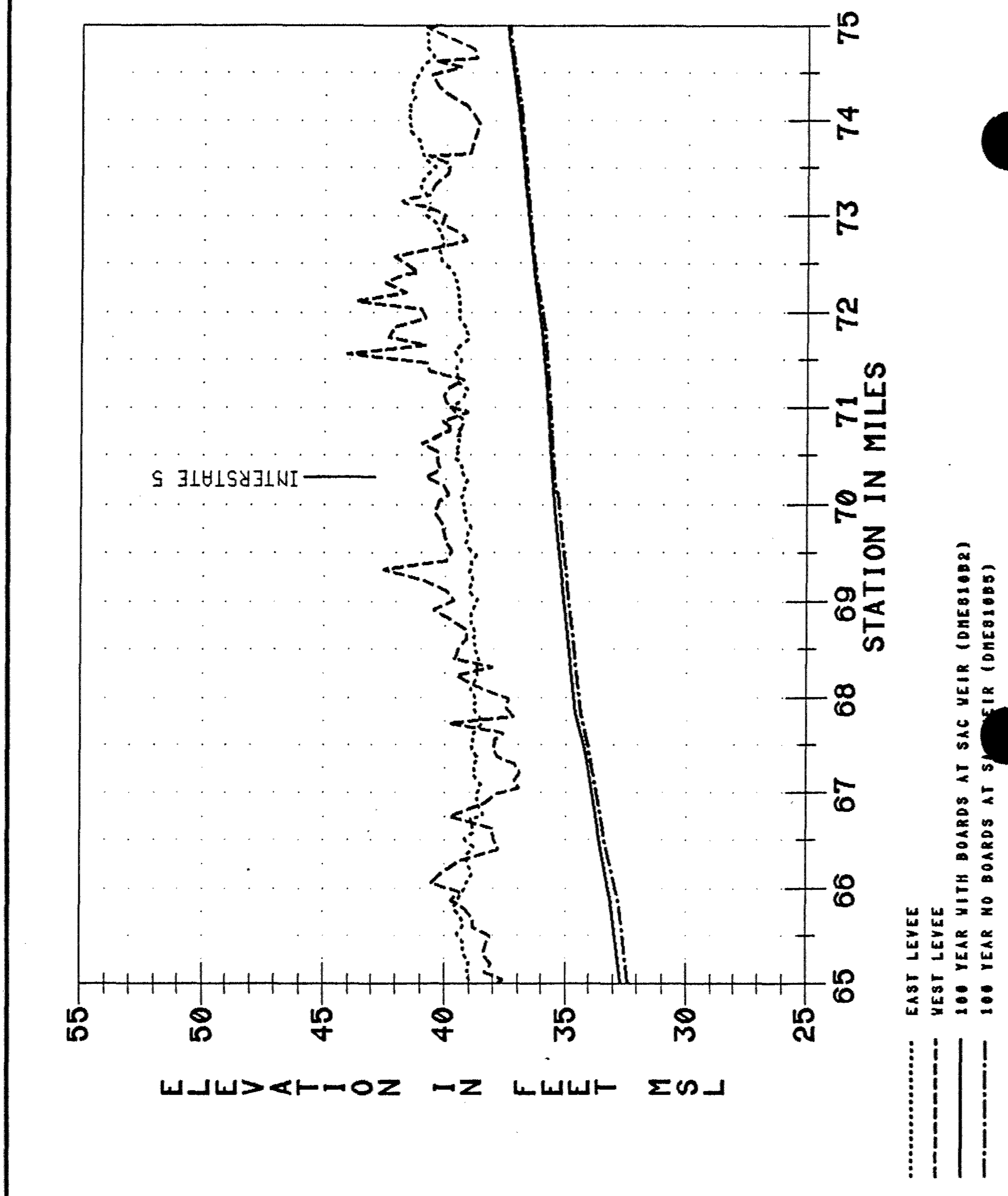
WATER SURFACE PROFILES
SACRAMENTO RIVER

SAC WEIR SENSITIVITY

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

SHEET 2 OF 4 CHART 48



SACRAMENTO METRO INVESTIGATION

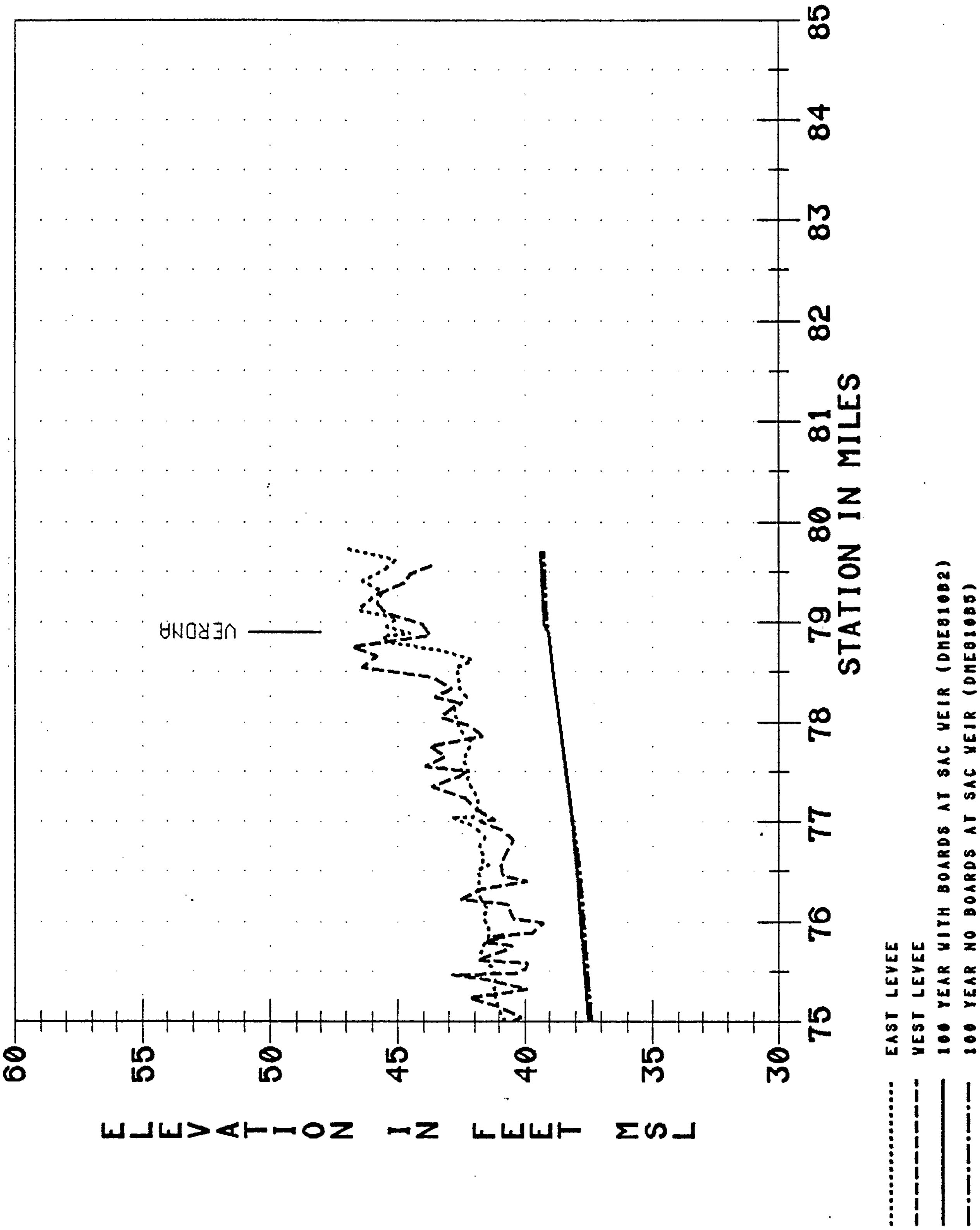
WATER SURFACE PROFILES SACRAMENTO RIVER

SAC WEIR SENSITIVITY

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.
Date: JUNE 1990

SHEET 3 OF 4 CHART 48



SACRAMENTO METRO INVESTIGATION

WATER SURFACE PROFILES SACRAMENTO RIVER

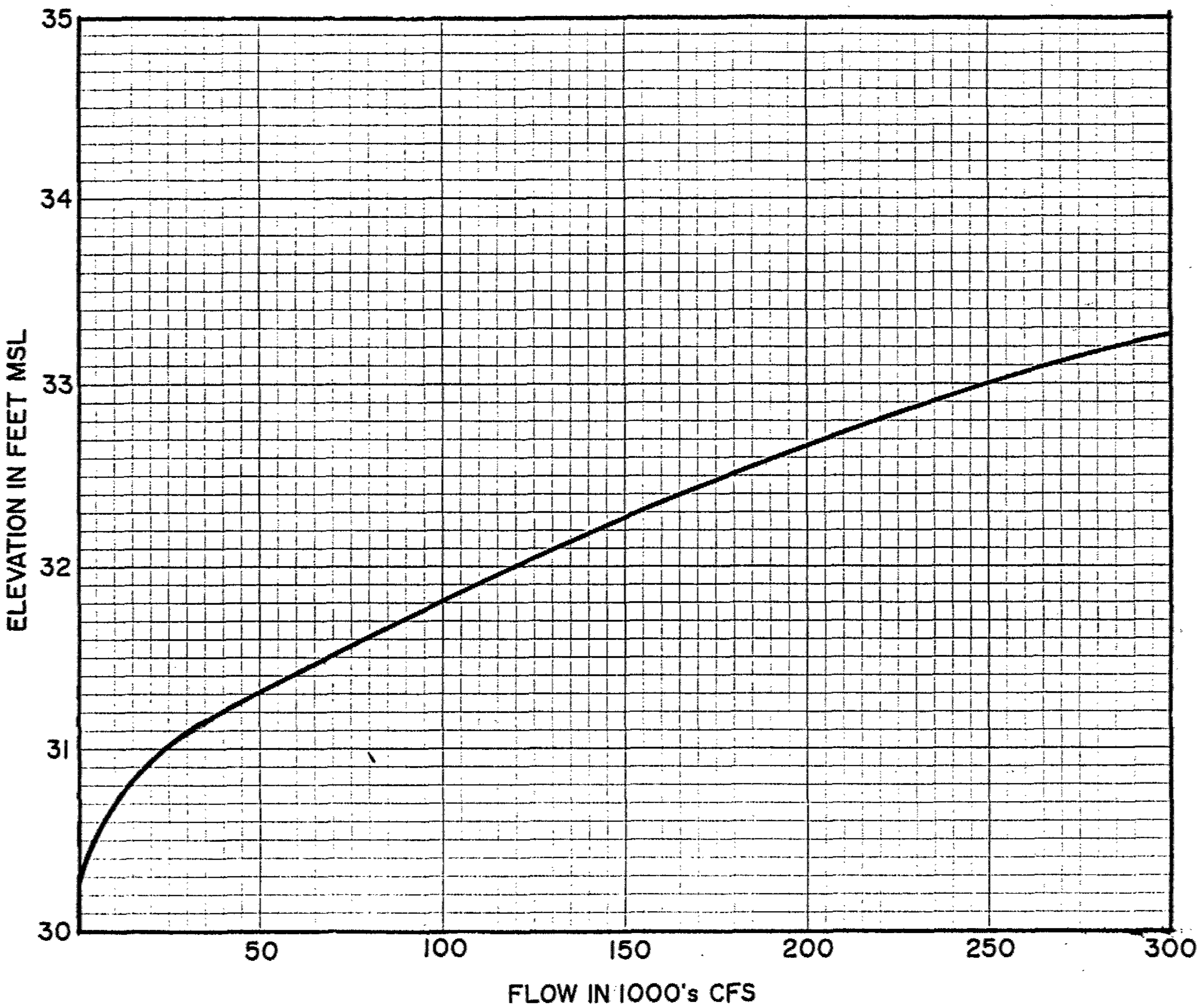
SAC WEIR SENSITIVITY

CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA

Prepared: J.H.
Drawn: J.H.

Date: JUNE 1990

SHEET 4 OF 4 CHART 48



NOTE:
THIS RATING CURVE MAY
NOT BE AN ACCURATE
RATING OF THE FREMONT WEIR.
SINCE SEDIMENT HAS BEEN
REMOVED FROM THE WEIR, NO
FLOW HAS OCCURRED OVER THE
WEIR SO NO FLOW MEASUREMENTS HAVE
BEEN MADE.

SACRAMENTO METRO INVESTIGATION
FREMONT WEIR RATING CURVE
CORPS OF ENGINEERS. SACRAMENTO. CALIFORNIA
Prepared: J.H. Drawn: J.H. Date: JUNE 1990

SACRAMENTO METROPOLITAN AREA, CALIFORNIA

FEASIBILITY REPORT

APPENDIX D

ENGINEERING BASIS OF DESIGN AND COST ESTIMATES

SACRAMENTO METROPOLITAN AREA

CALIFORNIA

ENGINEERING BASIS OF DESIGN AND COST ESTIMATES

FEBRUARY 1992

PREPARED BY

CENTRAL VALLEY SECTION, CIVIL PROJECTS BRANCH

ENGINEERING DIVISION

U. S. ARMY ENGINEER DISTRICT, SACRAMENTO

CORPS OF ENGINEERS

ENGINEERING BASIS OF DESIGN AND COST ESTIMATES

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT.)

LIST OF TABLES

LIST OF PLATES

TABLE OF CONTENTS (CONT.)

LIST OF ATTACHMENTS

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

ENGINEERING BASIS OF DESIGN AND COST ESTIMATES

1. GENERAL

The purpose of this Basis of Design is to address design aspects and cost estimates for increased levels of flood protection to West Sacramento by increasing the heights of approximately 25 miles of existing flood control levees. This report will describe the information used in determining alignment, freeboard, quantities, and costs for the different alternatives considered and will address the selected plan. Levee work is proposed in the urban areas of the city of West Sacramento, downstream from Sacramento Weir to the point where the Sacramento River Deep Water Ship Channel and Yolo Bypass East Levee come together. See Plate 1. Modifications investigated consist of raising existing levees. Design alternatives for different levels of flood protection were investigated. The alternatives are as follows:

1. 100-year flow on the Sacramento River and 115,000 cfs on the American River below Folsom Dam;
2. 200-year flow on the Sacramento River and 115,000 cfs on the American River below Folsom Dam;
3. 400-year flow on the Sacramento River and 115,000 cfs on the American River below Folsom Dam.

These alternatives reflect additional storage on the American River which would allow increased control of the releases from Folsom Dam for larger storms.

2. ALIGNMENT

Proposed levee work consists of raising existing levees with the alignment being determined by the existing alignment. Plate 1 shows the levees which currently exist in the West Sacramento area.

3. MAPPING AND TOPOGRAPHY

Levee topography was determined from recently surveyed levee profiles, and recent levee cross sections. In those reaches where cross sections were not available for existing levees, top widths were field verified and side slopes were assumed to be the same as used for the original design. These side slopes are: in the case of Yolo Bypass 3:1 landside and 4:1 waterside, and in the case of Sacramento Bypass 3:1 landside and 2:1 waterside. Where regularly spaced cross sections were not available, schematic sections were developed consistent in shape with field investigations. Field observations determined that most of the levees are consistent in shape. Therefore, the few sections that are provided serve to adequately represent long reaches of levee. Table 1 presents information on existing levee topography and sources

of information. Department of Water Resources levee profile survey data of 1989 was used for Putah Creek, Willow Slough Bypass, Sacramento River Right Bank, and Yolo Bypass right levee. 1989 Corps of Engineers cross section survey data was used for Yolo Bypass left levee.

During PED a mapping program will be done to develop topography along the levees to be modified. These maps will be on a scale of 1" = 50' and will show all physical features within 100 feet of both sides of the levee centerline. Cross sections will be taken every 400 feet along the centerline of the levees.

TABLE 1

EXISTING LEVEE INFORMATION AND SOURCES

REACH	TOP WIDTH (FT)	LEVEE PROFILE	SIDESLOPES LAND SIDE	SIDESLOPES WATER SIDE	HEIGHT (FT)
SACRAMENTO RIVER WEST LEVEE					
SAC WEIR TO CROSS LEVEE	20-40	1/	2:1	3:1	11-16
SACRAMENTO BYPASS					
NORTH LEVEE	25-30	1/	2:1	3:1	10-27
SOUTH LEVEE	20-30	2/	2:1	3:1	11-26
YOLO BYPASS EAST LEVEE					
SAC BYPASS TO SRDWSC **	20-30	2/	3:1	4:1	12-24
YOLO BYPASS WEST LEVEE					
WILLOW SL TO PUTAH CR	12-20	3/	2:1	3:1	15-21
NORTH OF WILLOW SL	12-15	3/	2:1	3:1	15-21
WILLOW SL BYPASS NORTH LEVEE	12	4/	2:1	3:1	5-9
WILLOW SL BYPASS SOUTH LEVEE	12	4/	2:1	3:1	6-13

** Sacramento River Deep Water Ship Channel

1/ From levee profile surveyed in October 1989 by the California Department of Water Resources.

2/ From levee cross sections surveyed by the Corps of Engineers in November 1989 and from levee profile surveyed in June 1988 by the California Department of Water Resources.

3/ From levee profile surveyed in June 1988 by the California Department of Water resources.

4/ From levee profile surveyed in August and September 1989 by the California Department of Water Resources.

4. DESIGN DETAILS

Design levee sections were chosen to remain the same as used in past designs for the existing levees. These sections have performed adequately and a stability analysis has determined that the levees would be stable after being raised to the elevations proposed for the alternatives, see Appendix E, geotech office report on enlargement of the levees. There are reaches of levees which have public roads on top of the levees. Where there are public roads and the levee must be modified, top widths of the levee will be the minimum safe roadway width of 28-feet. In determining whether new levee fill would be on the landside or waterside, consideration was given to the quantity of fill that was being placed and to impacts on utilities, relocations, and development. Table 2 lists the levee design details for the different levee reaches.

As part of the description of the existing system, a determination was made of where and when existing levees might be expected to fail in the study area. This determination was needed for economic analysis of benefits for the alternatives evaluated. The determination was based on engineering considerations as well as historical considerations and is enclosed at the end of this Basis of Design.

TABLE 2

DESIGN DETAILS FOR LEVEE REACHES

REACH	TOP WIDTH (FT)	SIDESLOPES LAND SIDE	SIDESLOPES WATER SIDE	SIDE OF FILL
SACRAMENTO RIVER WEST LEVEE				
SAC WEIR TO CROSS LEVEE	20	2:1	3:1	LANDSIDE
SACRAMENTO BYPASS				
NORTH LEVEE	28	2:1	3:1	LANDSIDE
SOUTH LEVEE	28	2:1	3:1	LANDSIDE
YOLO BYPASS EAST LEVEE				
SAC BYPASS TO SPRR *	20	3:1	4:1	WATERSIDE
SPRR TO YOLO CAUSEWAY	20	3:1	4:1	LANDSIDE
YOLO CAUSEWAY TO SRDWSC **	20	3:1	4:1	LANDSIDE
YOLO BYPASS WEST LEVEE				
WILLOW SL TO PUTAH CR	12	2:1	3:1	WATERSIDE
NORTH OF WILLOW SL	12	2:1	3:1	LANDSIDE
WILLOW SL BYPASS NORTH LEVEE	12	2:1	3:1	LANDSIDE
WILLOW SL BYPASS SOUTH LEVEE	12	2:1	3:1	LANDSIDE

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* Southern Pacific Railroad
** Sacramento River Deep Water Ship Channel

5. FREEBOARD

General

Design water surface profiles for the alternatives were developed using hydraulic and hydrologic models calibrated for the 1986 flood of record in most reaches. Because of this, the design profiles are considered to be very reliable for the design flows being considered. No additional freeboard above the minimum freeboard is considered necessary to account for uncertainties in design profile calculations for the alternatives.

The main objective of levee freeboard is to convey the design flows with a high degree of safety through the area of protection. Another objective is to design the levee in such a manner that flows exceeding the design flows will fail the levee in an area or in a manner that will cause the least amount of damage and have the least likelihood of causing loss of life, often referred to as levee superiority.

The freeboard adopted for the different levee reaches are: 3-feet for the Sacramento River West levee; 6-feet for the Sacramento Bypass South levee; 6-feet for the Yolo Bypass East Levee from the Sacramento Bypass to the Sacramento River Deep Water Ship Channel (SRDWSC); and 4-feet for the Yolo Bypass East Levee from the SRDWSC downstream. An additional three feet of freeboard was added to the regular 3 feet of freeboard for the bypasses for wave runup. Because of the width of the Yolo Bypass, substantial waves can be generated by winds during floods. The additional freeboard will prevent these waves from overtopping the levees and causing a wave erosion failure. The wave runup analysis is given in Chapter 7 of the Hydrology Report, Appendix C. This analysis indicates that wind set plus runup for design conditions is on the average about 6 feet. The 6-feet of freeboard is reduced to 4-feet at the SRDWSC because of the levee cross sections in this reach. The levee that divides the Yolo Bypass and the SRDWSC has a 5:1 waterside slope which reduces the wave runup. Also, the levees are wider with high berms behind the levees due to dredge disposal from the SRDWSC. These more substantial levees are not as susceptible to wave wash erosion as other levees along the Yolo Bypass. For these reasons, a reduction to 4-feet of freeboard is considered appropriate for these levee reaches.

Levee Superiority

Consideration was given to levee superiority for the designs. Different areas were considered for possible designed failures. Failures should not be designed along the north side of West Sacramento, because a failure here would allow flood flows to pass through the developed part of the study area on their way south and downstream. The only area where a levee failure might be designed to occur, would be south of the study area along the SRDWSC. Flows would still back into the developed area but would not flood the area as quickly as if the failure occurred on the north side. The design freeboard for the Yolo Bypass East Levee is already reduced along this reach and in essence provides for overtopping to first occur here should design flows be exceeded.

Table 3 lists the design freeboards adopted for the alternatives for the different levee reaches

TABLE 3

DESIGN FREEBOARD FOR LEVEE REACHES

REACH	DESIGN FREEBOARD (FEET)
SACRAMENTO RIVER WEST LEVEE	3
SACRAMENTO BYPASS SOUTH LEVEE	6
YOLO BYPASS EAST LEVEE	
SAC BYPASS TO SRDWSC **	6
DOWNSTREAM FROM SRDWSC	4

** Sacramento River Deep Water Ship Channel

6. SEDIMENTATION AND EROSION PROTECTION

Sacramento River Flood Control System

The Sacramento River Flood Control System is a system of levees, overflow weirs, and leveed bypass floodways. The Sacramento River itself is leveed along most of its length below Chico Landing. As flows exceed the capacity of the Sacramento River, they are diverted over the overflow weirs and into the bypasses. Hydraulic mining in the Sierra Mountains deposited huge amounts of sediment in the Sacramento Basin floodplain in the late 1800's. The rivers began to incise into these deposits and to move the sediment downstream. In addition, erosion of river banks along the upper Sacramento River continues to contribute large sediment loads to the system. The system is designed to constrict flows to the leveed river channel for as long as possible. This constriction enables the system to transport most of the sediment load through the system and into the bays and estuaries downstream. Deposition does occur at the weirs and in the bypasses when flood flows are diverted into them.

Fremont Weir

The Fremont Weir was completed in 1929. It is located at the confluence of the Sacramento River, Feather River, and Sutter Bypass. Flood flows are diverted over the weir and into the Yolo Bypass. The weir had been in operation for 57 years when the flood of 1986 occurred. Sediment has deposited in the area of the weir through its years of operation and the 1986 flood indicated that this sediment may have begun to impact the operation of the weir. The Department of Water Resources instituted a program of sediment removal in 1986. During 1986 and 87 approximately two-thirds of the sediment, 500,000 cubic yards (CY) in 1986 and 600,000 CY in 1987, was removed from the surrounding area of the weir, with the area being excavated to a point below the elevation of the weir along much of its reach. The remaining sediment, approximately 700,000 CY, is being removed in 1991. This is the first time that sediment has been removed from the Fremont Weir. Hydrologic analysis for

this study has incorporated the flow changes caused by this sediment removal. The Department of Water Resources intends to maintain this area so that the operation of the weir is not impacted.

Yolo Bypass

The Yolo Bypass is a leveed bypass which receives the flows which pass over the Fremont Weir. These flows begin when flows in the Sacramento River below the Fremont Weir exceed approximately 60,000 cfs. The bypass varies in width from about 7,000 feet near the Fremont Weir to about 16,000 feet at Interstate Highway 80 (I-80). The area within the bypass is extensively farmed. Information developed from the sediment transport studies for "Sacramento River and Tributaries Bank Protection and Erosion Control Investigation, California", Corps of Engineers, August 1983, indicates that sediment deposition within the Yolo Bypass could have an adverse impact on flood stages and design flow requirements. Based on the sediment budgets contained in this report, long term averages of about 580,000 tons and 150,000 tons of sediment are discharged annually over the Fremont and Sacramento Weirs respectively, into the Yolo Bypass. Of the 730,000 tons of sediment discharged over the two weirs, about 429,000 tons (318,000 CY) are deposited annually in the bypass. Currently, about 200,000 tons of sediment are deposited in the Yolo Bypass by Cache Creek. The majority of this material is deposited in an area just downstream of the existing cobble weir. After the Cache Creek settling basin is modified, sediments from Cache Creek are not expected to deposit in the bypass, as noted in the report, "Cache Creek Basin, California," Corps of Engineers, February 1979. This project should be completed in 1992. Additional sediments are transported into the Yolo Bypass from smaller tributaries and from agricultural return water.

Under existing conditions (no improvements at the Cache Creek settling basin), about 466,000 CY of sediment are deposited annually into the Yolo Bypass from Sacramento River overflow and from Cache Creek. If spread uniformly over the surface area of the bypass, 466,000 CY of sediment would represent a depth of about 0.05 inch of deposited material per year (2.5 inches of deposited material in a 50-year period). The effect of sediment deposition on flood stages in the Yolo Bypass could be more significant than indicated, because the sediments probably accumulate in specific areas. At present, there is no procedure for monitoring sediment deposition and sediment deposits are not being removed from the Yolo Bypass. However, the 6-feet of freeboard used for the Yolo Bypass design is considered adequate to accommodate any changes in design flood stages caused by this projected future sedimentation.

Sacramento River - Verona to Sacramento

This reach of the river is downstream of the Fremont Weir and carries those flows from the Sacramento River, Feather River, and Sutter Bypass which do not pass over the Fremont Weir. As mentioned, flow remains in the Sacramento River until approximately 60,000 cfs at which point flows also begin over the Fremont Weir. Information developed from the sediment budget analysis in the "Sacramento River and Tributaries Bank Protection and Erosion Control Investigation, California", Corps of Engineers, August 1983, indicates that sediment deposition should take place in this reach of the river. Based on the sediment budgets contained in this report, long term averages of about 330,000 tons annually are deposited. However, a comparison of the rating

curves developed by the USGS for the Sacramento River at Verona over time indicates just the opposite. Plate 2 shows the trend for the curve to shift to the right, which indicates increased conveyance through the years. The increased capacity is attributed to channel degradation, probably a combination of bottom scour and channel enlargement. This would indicate that the operational objective of maintaining flows in the Sacramento River for as long as possible to prevent depositional build-up is working.

Recent Findings

Geomorphic analysis done for the Sacramento River Bank Protection Project have determined that the rivers have incised through most of the erosive hydraulic mining sediments. Existing bank protection has stabilized the reaches of the Sacramento River in the study area. The Feather River lower bank is composed of resistant slickens underlain by intermittently non-cohesive and erodible deposits. Although the river is relatively stable now, should the slickens be eroded, the channel could begin to change quickly. Incision into this strata is not considered imminent but should be monitored.

Future Studies

At the beginning of PED additional hydraulic and sediment analysis will be done to verify the design used for this project. A two-dimensional hydraulic model will be developed for the Sacramento River - Feather River confluence and Fremont Weir area. This model will verify flows at this complex juncture and investigate sensitivity of abnormal sediment movements. Sediment analysis will be done either with the two-dimensional model or separately to further define existing and potential sediment movement through the system. Feather River potential downcutting will receive special emphasis. Cross-sections established by the USGS in 1979 will be resurveyed to attempt to identify any possible areas of extreme deposition in the Yolo Bypass. Design freeboard for the proposed project will be adjusted if required. If these future studies indicate a need, a monitoring program will be established to continue to track any depositional problems.

Erosion

Erosion potential along the modified levees and the need for erosion protection were also considered. Velocities along the levees are not high enough to cause erosion. However, erosion due to wavewash must be considered. Initially the 4 to 1 side slopes used on the waterside of the levees which serve to reduce erosion potential from wavewash were thought to eliminate the need for wavewash protection. However, after further investigation of the erosion which took place during the 1986 flood and consideration of the height of waves which can be generated in the Yolo Bypass, this was reconsidered. Field investigation showed that riprap for wavewash protection already exists along most reaches of the levee. This riprap extends from the toe of the levee to about four feet from the top of levee. Coordination with RD 900 which maintains the existing levees determined that wavewash erosion is a concern and has been a problem during floods at several spots along the reaches being modified. Therefore it was decided to place riprap on the raised levees to protect against wavewash erosion. A twelve inch blanket of riprap will be placed so as to tie into the existing riprap and will extend up to two feet from the top. The reach of the east levee of the Yolo Bypass between the SPRR and I-80 is covered by a concrete lining. This lining is in

an extreme state of disrepair. Gaps exist which have been filled with rock. This lining will be removed and replaced with riprap when the levee is raised. This is to insure congruous protection against wavewash along all reaches.

7. RELOCATIONS

Two major transportation routes cross the project levees in the reach where modifications are proposed, a Southern Pacific Railroad (SPRR) line and I-80. Plate 1 shows the location of these crossings. Major modifications would be necessary to these lines if they were raised to the proposed elevations of the new levees.

The SPRR railroad grade is approximately one foot above the investigated design water surfaces. If this railroad were modified to pass over the proposed increased levee heights, a long length of railroad line would have to be raised at great expense. To raise the railroad would require the construction of a temporary rail line while raising the permanent rail line. Instead of raising the railroad, a flood gate structure could be installed at the railroad crossing. This structure would have concrete walls on both sides and parallel to the tracks. These walls would abut the levee. A concrete sill would be installed for the tracks between the walls. Between the walls, a gate would be constructed, which would be closed and sealed during floods. A preliminary cost comparison was developed to demonstrate the economics of these two methods of addressing the railroad.

To raise the railroad would cost approximately $300,000. To install the proposed flood gate would cost $70,000. As described below, the flood gate would be closed very infrequently, if at all, and for short periods of time. The cost of disruption to railroad traffic over the life of the project would not offset this difference in first cost for the two methods. The flood gate is the adopted procedure for addressing the railroad crossing.

The flood gate would remain open until flood elevations reached a predetermined critical elevation. At that time, the gate would be closed and remain closed until flood elevations dropped below the critical elevation. Flood elevations do not rapidly rise in the Yolo Bypass. The critical flood elevation would be selected to give adequate time to close and seal the flood gate. The gate itself is proposed to be entirely within the freeboard of the levee and would not have flood water against it unless design flows were exceeded. Therefore the flood gate could remain open until the design flood occurred which means that the gate would be closed on the average of once every 400 years. The flood gate closure would receive careful monitoring during the passage of a flood and a monitoring system would be installed which would alert local flood officials when flood elevations reached the critical elevation. The use of a flood gate could interrupt railroad traffic for several days. However, this would occur very infrequently. These type of flood gates are currently in use in other reaches of the Sacramento River Flood Control Project.

The effects of increased water surfaces on the SPRR Bridges due to the proposed levee raising were also considered. These bridges are currently wooden trestles. The rail line is a double track line with east and west routes. Coordination with the Southern Pacific Railroad determined that the railroad is replacing the existing wooden trestles with steel pile and concrete cap and deck trestles. These more stable and anchored structures are

considered adequate to withstand the small increases in water surface due to the proposed levee modifications. The 1986 flood substantially encroached upon the wooden trestles and there were no problems at that time.

The grade of I-80 is approximately 4 feet above the proposed design water surface elevations. As with the SPRR, modification of this crossing to go over the proposed levee raising would be expensive. The existing crossing is a wide concrete bridge. The existing four foot of freeboard is adequate for most unknowns. The only freeboard that is lacking is design freeboard added to prevent overtopping due to waves. The concrete roadway serves to prevent any wave wash from passing over the levee at this crossing. In addition, parapet walls on both sides of the roadway, would serve as additional wavewash freeboard. Where the modified levee abuts the roadway, riprap or concrete would be placed to prevent erosion of the levee ends where wave wash could occur. This low point in the levee reach would not jeopardize the integrity of the levee system.

8. HYDRAULIC MITIGATION

In a levee system as complex as the one which surrounds West Sacramento, any change in levee heights in one area can very likely cause impacts on other levees in the system. These impacts can be caused by reduced conveyance due to levee fill or by loss of flood storage due to prevention of levee failure. These impacts generally take the form of increased water surface elevations for a particular design flow and mitigation for these impacts should be investigated. The measures taken to address project induced flooding impacts are called hydraulic mitigation to differentiate from fish and wildlife mitigation. The approach used in this study for hydraulic mitigation is to assure that no area's flood frequency, for an impacted reach of levee, would be worse after the proposed levee modifications were done. This would be assured by raising low areas of impacted levees so as to restore other protected area's flood frequency to at least the same level as existed before levee modifications. In the case of the Sacramento Metropolitan Study, the proposed levee modifications indicate an increase in water surface by a maximum of 0.9 foot in some reaches. Therefore, for hydraulic mitigation purposes, other levees impacted by the proposed levee modifications would have low elevation reaches raised to restore their previous flood protection.

9. INTERIOR DRAINAGE

The City of West Sacramento has an existing interior drainage system for the existing levees. This system was recently analyzed for the City's general plan. The area within the city is divided into eight major drainage sheds which encompass approximately 12,000 acres. Three reclamation districts serve the City's trunk storm drainage and flood protection needs. These are RD 537, RD 811, and RD 900. The current interior drainage system is composed of storm drain laterals and trunks which drain to canals that either drain to the Deep Water Ship Channel or to pumping stations. These stations pump water to either the Yolo Bypass, the Sacramento River Deep Water Ship Channel, or the Sacramento River. The drainage canals are large enough to serve as storage or detention basins. Given below is information on the existing pump stations:

STATION NAME	NUMBER OF PUMPS	PUMPING CAPACITY	DISCHARGES TO
CHP ACADEMY	5	320 CFS	YOLO BYPASS
RACE TRACK	2	100 CFS	YOLO BYPASS
CAUSEWAY	UK*	100 CFS	YOLO BYPASS
MAIN CANAL	4	400 CFS	SRDWSC
LIGHTHOUSE MARINA	UK*	UK*	SACRAMENTO RIVER
RALEY'S LANDING	UK*	UK*	SACRAMENTO RIVER

* UK = Unknown

The City of West Sacramento General Plan has investigated improvements required to the drainage system which will be necessary as planned development occurs. In most cases these improvements are designed to limit the 100-year elevations within the drainage system. These improvements include larger trunk lines and additional pumping stations. None of these improvements are necessary because of the proposed levee work in this study.

West Sacramento has a plan to handle the current and future interior drainage. The proposed raising of the levees does not alter the existing drainage patterns or the current operation of the existing system. No modifications to the drainage system are proposed as a part of this flood control project. An item of local cooperation will be added to the Local Cooperation Agreement to better define the local sponsor's responsibility for increased interior drainage due to future development.

10. ALTERNATIVE DESIGNS; DESCRIPTIONS AND COSTS

The alternative plans will provide different levels of flood protection to the West Sacramento area. All of the alternative design profiles are within one foot of elevation for the Yolo Bypass. Costs for the alternatives were computed by developing detailed quantities and costs for the designs. Below is a description of levee work required for the different reaches of levee modification.

10.1 SACRAMENTO BYPASS SOUTH BANK LEVEE:

Levee modifications will occur over 5,800 feet of levee. The existing levee width varies from 25 feet to 42 feet, and the proposed levee width is 28 feet. The maximum levee raising is 5.4 feet.

Design costs for this reach are shown in Table 4.

TABLE 4

SACRAMENTO BYPASS SOUTH LEVEE
ALTERNATIVE COSTS

OCTOBER 1991 PRICE LEVEL

COST ITEMS	100-YR SAC 115K CFS AMR	200-YR SAC 115K CFS AMR	400-YR SAC 115K CFS AMR
01 LANDS	1,680,000	2,120,000	2,210,000
02 RELOCATIONS	80,000	80,000	80,000
11 LEVEES	680,000	810,000	820,000
30 ENGINEERING & DESIGN	100,000	110,000	110,000
31 SUPERVISION & ADMIN.	60,000	80,000	80,000
TOTAL FIRST COST	2,600,000	3,200,000	3,300,000

10.2 YOLO BYPASS EAST BANK LEVEE:

Modifications will occur over 24,800 feet of levee. The existing levee width varies from 20 feet to 30 feet, and the proposed levee width is 20 feet. The maximum increase in levee height is 6.0 feet.

Design costs for this reach are shown in Table 5.

It should be noted here that this section of Yolo Bypass is divided into three subreaches as follows:

10.2.1 Sacramento Bypass South Bank Levee to Southern Pacific Railroad;

10.2.2 Southern Pacific Railroad to Yolo Causeway;

10.2.3 Yolo Causeway to Sacramento River Deep Water Ship Channel (SRDWSC)

A special gotechnical analysis of the three subreaches was conducted and determined that the levees would be safe when they are raised from the present elevations to as much as 6 to 7 feet. This study was necessary because of local sponsor concerns for the stability of these levee reaches after they are raised. This study is presented in Appendix E.

For reach 10.2.1 the recommendation is to raise the levee on the waterside to avoid construction in an existing large drainage ditch. An inspection trench beneath the expanded levee section is also recommended.

For reach 10.2.2 the recommendation is to raise the levee on the landside, which will also protect the habitat on the waterside. Along the waterside slope, there is an old broken concrete wall and armoring slab surface. This old concrete slab will be demolished and removed, before the new embankment is constructed. There exists a 2,300 foot long drainage ditch in this reach. The necessity of backfilling and relocation prior to enlarging the levee will be investigated. The existing gravel stability berm will require extension, starting from the existing berm and ending at the new landside levee toe. The excavation of an inspection trench beneath the expanded levee section is also recommended.

For reach 10.2.3 the recommendation is to raise the levee on the landside. It is recommended that an inspection trench be excavated beneath the expanded levee section. In addition to the inspection trench, all drainage ditches located within 50 feet of the landside toe will be backfilled and relocated.

TABLE 5

YOLO BYPASS EAST LEVEE
ALTERNATIVE COSTS

OCTOBER 1991 PRICE LEVEL

COST ITEMS	100-YR SAC 115K CFS AMR	200-YR SAC 115K CFS AMR	400-YR SAC 115K CFS AMR
01 LANDS	6,180,000	6,690,000	6,730,000
02 RELOCATIONS	50,000	50,000	50,000
11 LEVEES	5,380,000	6,220,000	6,250,000
30 ENGINEERING & DESIGN	650,000	750,000	760,000
31 SUPERVISION & ADMIN.	440,000	490,000	510,000
TOTAL FIRST COST	12,700,000	14,200,000	14,300,000

10.3 MITIGATION COSTS FOR ALL SEVEN DESIGNS

The raising of levees to provide greater level of flood protection to the West Sacramento Area will affect the level of flood flows in the Yolo Bypass. Hydrologic analysis has determined that this impact could be as much as 0.9 foot on other levees in the system for the 400-year flood. Lower levels of design will have less severe impacts. These impacted levees will have low levee elevations in certain reaches raised to maintain their existing level of protection.

However, the approach for mitigation for the Sacramento Bypass North Levee is different than explained. It was initially determined that it was

important for the bypass to function under all conditions. For this reason the north levee was raised to the same height as the south levee as a mitigation measure during the alternatives evaluation. This assumption will receive further review during detailed design of the selected plan. The mitigation approach for the Sacramento Bypass North Levee may be the same as for all other impacted levees for the selected plan.

Other impacted levees include 20,500 feet of the Yolo Bypass West Levee south of Willow Slough Bypass Levee and 11,800 feet of Yolo Bypass West Levee north of Willow Slough Bypass Levee. Also to be raised are the North and South Willow Slough Levees over the lowest elevations and includes 4,100 feet of the North Levee and 9,700 feet of the South Levee.

A military transmission station on the west side of the Yolo Bypass will also be affected by the project. This station is not protected by any existing levee and would be flooded under existing conditions. The project effect would be to increase the depth of flooding by approximately 0.9 foot. The mitigation approach for this station is to build a ring levee around the facility. This levee would be 12,000 feet long and have a maximum height of seven feet.

RD 2068 at the lower end of the bypass would also be affected. Approximately 5,000 feet of low levee in the middle of the district will be raised to mitigate for project impacts.

Table 6 shows the costs for hydraulic mitigation detailed by mitigation reach.

TABLE 6

HYDRAULIC MITIGATION COSTS

OCTOBER 1991 PRICE LEVEL

SACRAMENTO BYPASS NORTH BANK LEVEE

COST ITEMS	100-YR SAC 115K CFS AMR	200-YR SAC 115K CFS AMR	400-YR SAC 115K CFS AMR
01 LANDS	120,000	160,000	160,000
02 RELOCATIONS	260,000	260,000	260,000
11 LEVEES	1,250,000	1,540,000	1,560,000
30 ENGINEERING & DESIGN	180,000	210,000	210,000
31 SUPERVISION & ADMIN.	130,000	130,000	130,000
TOTAL FIRST COST	1,940,000	2,300,000	2,320,000

YOLO BYPASS WEST LEVEE
PUTAH CR. TO WILLOW SL. BYPASS

COST ITEMS	100-YR SAC 115K CFS AMR	200-YR SAC 115K CFS AMR	400-YR SAC 115K CFS AMR
01 LANDS	0	0	0
02 RELOCATIONS	0	0	0
11 LEVEES	630,000	1,000,000	1,330,000
30 ENGINEERING & DESIGN	80,000	120,000	170,000
31 SUPERVISION & ADMINIS.	50,000	80,000	110,000
TOTAL FIRST COST	760,000	1,200,000	1,610,000

TABLE 6 (CONT.)

HYDRAULIC MITIGATION COSTS

YOLO BYPASS WEST LEVEE
WILLOW SL. NORTH

COST ITEMS	100-YR SAC 115K CFS AMR	200-YR SAC 115K CFS AMR	400-YR SAC 115K CFS AMR
01 LANDS	0	0	0
02 RELOCATIONS	0	0	0
11 LEVEES	340,000	410,000	580,000
30 ENGINEERING & DESIGN	40,000	50,000	70,000
31 SUPERVISION & ADMINIS.	20,000	40,000	50,000
TOTAL FIRST COST	400,000	500,000	700,000

WILLOW SLOUGH BYPASS NORTH LEVEE

COST ITEMS	100-YR SAC 115K CFS AMR	200-YR SAC 115K CFS AMR	400-YR SAC 115K CFS AMR
01 LANDS	0	0	0
02 RELOCATIONS	0	0	0
11 LEVEES	130,000	200,000	270,000
30 ENGINEERING & DESIGN	20,000	30,000	30,000
31 SUPERVISION & ADMINIS.	10,000	20,000	20,000
TOTAL FIRST COST	160,000	240,000	320,000

TABLE 6 (CONT.)

HYDRAULIC MITIGATION COSTS

WILLOW SLOUGH BYPASS SOUTH LEVEE

COST ITEMS	100-YR SAC 115K CFS AMR	200-YR SAC 115K CFS AMR	400-YR SAC 115K CFS AMR
01 LANDS	0	0	0
02 RELOCATIONS	0	0	0
11 LEVEES	170,000	250,000	330,000
30 ENGINEERING & DESIGN	20,000	30,000	40,000
31 SUPERVISION & ADMINIS.	10,000	20,000	30,000
TOTAL FIRST COST	200,000	300,000	400,000

MILITARY TRANSMISSION STATION

COST ITEMS	100-YR SAC 115K CFS AMR	200-YR SAC 115K CFS AMR	400-YR SAC 115K CFS AMR
01 LANDS	0	0	0
02 RELOCATIONS	5,000	5,000	5,000
11 LEVEES	1,150,000	1,160,000	1,160,000
30 ENGINEERING & DESIGN	140,000	140,000	140,000
31 SUPERVISION & ADMINIS.	90,000	90,000	90,000
TOTAL FIRST COST	1,385,000	1,395,000	1,395,000

TABLE 6 (CONT.)

HYDRAULIC MITIGATION COSTS

RD 2068
COSTS ARE THE SAME FOR ALL DESIGN ALTERNATIVES

COST ITEMS	100-YR SAC 115K CFS AMR	200-YR SAC 115K CFS AMR	400-YR SAC 115K CFS AMR
01 LANDS	0	0	0
02 RELOCATIONS	5,000	5,000	5,000
11 LEVEES	210,000	210,000	210,000
30 ENGINEERING & DESIGN	20,000	20,000	20,000
31 SUPERVISION & ADMINIS.	20,000	20,000	20,000
TOTAL FIRST COST	255,000	255,000	255,000

TOTAL HYDRAULIC MITIGATION COSTS

COST ITEMS	100-YR SAC 115K CFS AMR	200-YR SAC 115K CFS AMR	400-YR SAC 115K CFS AMR
01 LANDS	120,000	160,000	160,000
02 RELOCATIONS	270,000	270,000	270,000
11 LEVEES	3,880,000	4,770,000	5,440,000
30 ENGINEERING & DESIGN	500,000	600,000	680,000
31 SUPERVISION & ADMINIS.	330,000	400,000	450,000
TOTAL FIRST COST	5,100,000	6,200,000	7,000,000

10.4 TOTAL FIRST COST AND TOTAL ANNUAL COST

The Total First Cost which includes the Real Estate, Relocations, Levee Raising, Engineering & Design, and Supervision & Administration costs for all design alternatives are given in Table 7. This table also includes an estimate for easement lands required for hydraulic mitigation and an estimate for environmental mitigation required for each alternative.

TABLE 7

TOTAL PROJECT COST FOR EACH ALTERNATIVE

OCTOBER 1991 PRICE LEVEL

COST ITEMS	100-YR SAC 115K CFS AMR	200-YR SAC 115K CFS AMR	400-YR SAC 115K CFS AMR
01 LANDS	2,100,000	2,500,000	2,700,000
EASEMENT LANDS	3,500,000	3,600,000	3,800,000
02 RELOCATIONS	400,000	400,000	400,000
06 FISH AND WILDLIFE FAC	3,500,000	3,500,000	3,500,000
11 LEVEES	11,940,000	14,300,000	15,130,000
18 CULTURAL RESOURCES	190,000	220,000	230,000
30 ENGINEERING & DESIGN	2,060,000	2,370,000	2,470,000
31 SUPERVISION & ADMINIS.	1,270,000	1,460,000	1,520,000
TOTAL FIRST COST	24,960,000	28,350,000	29,750,000
	ANNUAL COSTS		
INTEREST DURING CONSTRUCTION	2,580,000	2,980,000	3,110,000
TOTAL FIRST INVESTMENT	27,540,000	31,330,000	32,860,000
INTEREST RATE	8.750%	8.750%	8.750%
ANALYSIS PERIOD (YEARS)	100	100	100
INTEREST & AMORTIZATION ANNUAL COSTS	2,410,000	2,740,000	2,880,000
O,M & R COSTS	20,000	20,000	20,000
TOTAL ANNUAL COSTS	2,430,000	2,760,000	2,900,000

Removal of Hydraulic Mitigation

Upon further review, it was decided that the study should evaluate the cost for hydraulic mitigation against the induced impacts of the project. This evaluation is discussed in the main report in Chapter 4, Plan Formulation, in the section titled, "Hydraulic Impact Analysis". The complete detailed evaluation is attached at the end of this appendix. Based on this evaluation, which included a legal taking analysis, it was determine that the induced impacts do not create an additional flood hazard or interfere with the present beneficial use of the land. Therefore, hydraulic mitigation was not necessary and the alternatives should be evaluated with the cost for hydraulic mitigation measures removed from the plans. Table 8 gives total project costs and annual costs for the alternatives without hydraulic mitigation measures.

TABLE 8

TOTAL PROJECT COST FOR EACH ALTERNATIVE
WITHOUT HYDRAULIC MITIGATION MEASURES
OCTOBER 1991 PRICE LEVEL

COST ITEMS	100-YR SAC 115K CFS AMR	200-YR SAC 115K CFS AMR	400-YR SAC 115K CFS AMR
01 LANDS	2,000,000	2,400,000	2,500,000
02 RELOCATIONS	130,000	130,000	130,000
06 FISH AND WILDLIFE FAC	3,200,000	3,200,000	3,200,000
11 LEVEES	8,060,000	9,520,000	9,690,000
18 CULTURAL RESOURCES	130,000	150,000	160,000
30 ENGINEERING & DESIGN	1,480,000	1,670,000	1,690,000
31 SUPERVISION & ADMINIS.	910,000	1,030,000	1,040,000
TOTAL FIRST COST	15,910,000	18,100,000	18,410,000
ANNUAL COSTS			
INTEREST DURING CONSTRUCTION	1,930,000	2,200,000	2,230,000
TOTAL FIRST INVESTMENT	17,840,000	20,300,000	20,640,000
INTEREST RATE	8.750%	8.750%	8.750%
ANALYSIS PERIOD (YEARS)	100	100	100
INTEREST & AMORTIZATION ANNUAL COSTS	1,560,000	1,780,000	1,810,000
O,M & R COSTS	20,000	20,000	20,000
TOTAL ANNUAL COSTS	1,580,000	1,800,000	1,830,000

11. SELECTED PLAN

The selected plan for protection of West Sacramento is the NED plan. This plan provides protection against the 400-year flood. The plan will require an increase in heights of levees along the south side of the Sacramento Bypass and along the east side of the Yolo Bypass from the Sacramento Bypass to the Sacramento River Deep Water Ship Channel. Table 9 presents a description of the modifications required for the selected plan. As can be seen approximately 5.7 miles of existing levee will have to be raised a maximum of 5.5 feet to provide 400-year protection to West Sacramento. Riprap will be placed on the waterside of the raised levees and existing riprap will be extended to provide erosion protection against wavewash. Plate 3 shows typical details to be used in raising the levees. Plates 4 and 5 show the new levee crown profiles.

Design freeboard was modified slightly from what was discussed earlier for the Sacramento Bypass. Since the wave action of the Yolo Bypass does not reach into the upper reaches of the Sacramento Bypass, it was determined that the design freeboard in this upper reach could be reduced. Therefore, design freeboard in the Sacramento Bypass is 4 feet in the upper 2000 feet of the bypass and is increased to 6 feet along the lower reach where it joins the Yolo Bypass. Design freeboard along the Yolo Bypass was still held at 6 feet to the SRDWSC where it was reduced to 4 feet as described in the earlier discussion of freeboard.

The selected plan includes a flood control gate to be provided at the SPRR instead of raising the railroad over the modified levee. This gate and its operation were described earlier in this report.

TABLE 9

SELECTED PLAN
DESCRIPTION OF PLAN MODIFICATIONS

REACH	MODIFIED REACH LENGTH (MI)	MAXIMUM LEVEE HEIGHT INCREASE (FT)	ADDITIONAL RIGHT OF WAY (AC)	REMARKS
SACRAMENTO BYPASS SOUTH LEVEE	1.0	5.0	2.5	RAISE LEVEE LANDSIDE
YOLO BYPASS EAST LEVEE				
SACRAMENTO BYPASS TO SPRR	1.1	5.5	4.1	RAISE LEVEE WATERSIDE
SPRR TO I-80	1.0	5.0	4.2	RAISE LEVEE LANDSIDE, INSTALL FLOOD GATE AT SPRR
I-80 TO SRDWSC	2.6	5.5	7.7	RAISE LEVEE LANDSIDE

NOTE: Yolo Bypass levees will have riprap extended or placed to provide erosion protection against wavewash.

The project cost for the selected plan is given in Table 10. The MCACES Cost Estimate is attached at the end of this appendix.

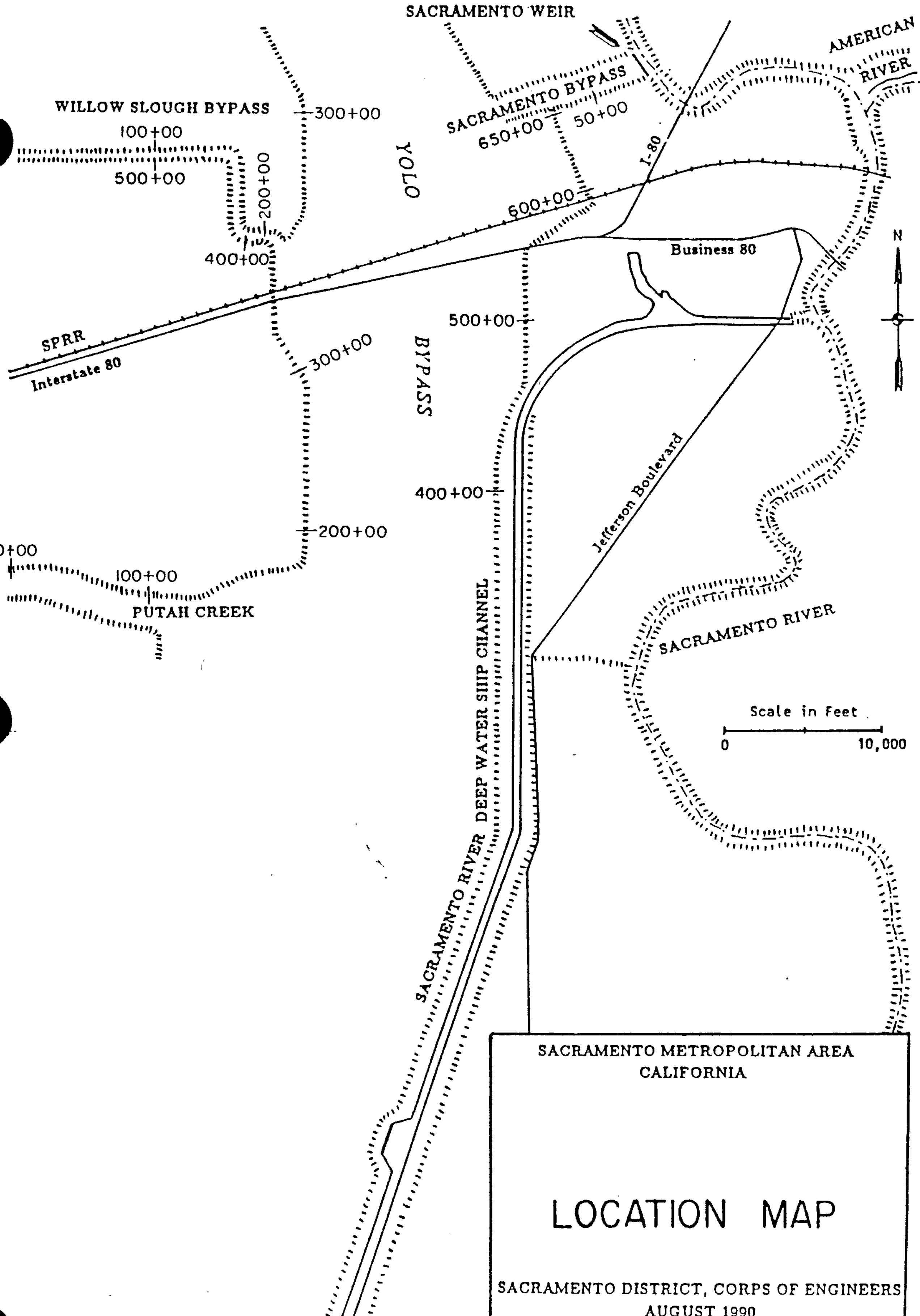
TABLE 10

PROJECT COST ESTIMATE

SELECTED PLAN

01	LANDS AND DAMAGES	$ 1,880,000
02	RELOCATIONS	15,000
06	FISH AND WILDLIFE FACILITIES	2,400,000
11	LEVEES	10,200,000
18	CULTURAL RESOURCE PRESERVATION	131,000
30	PLANNING, ENGINEERING, AND DESIGN	1,665,000
31	CONSTRUCTION MANAGEMENT	1,132,000
	TOTAL PROJECT COST	$ 17,423,000

PLATES

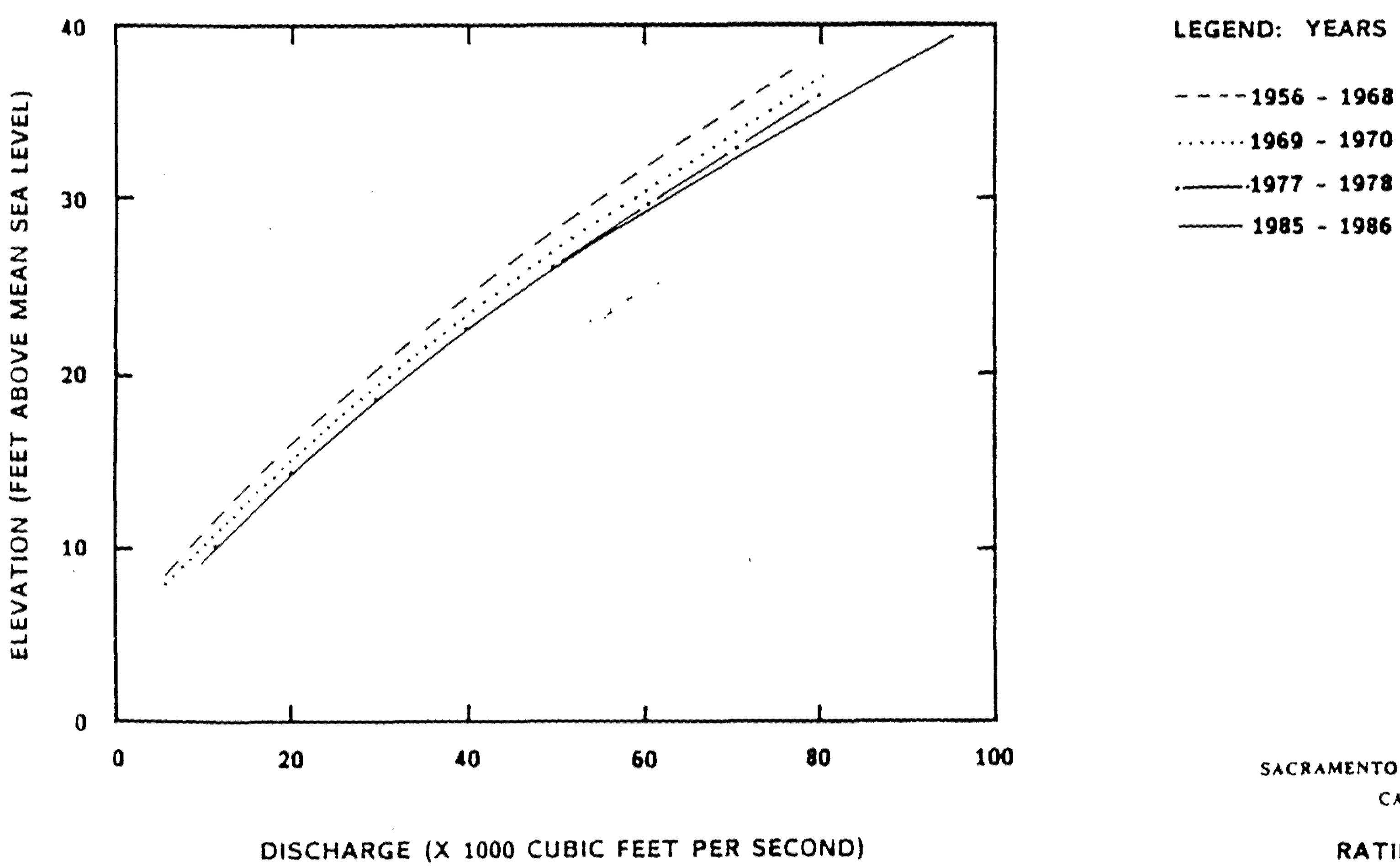


SACRAMENTO METROPOLITAN AREA
CALIFORNIA

LOCATION MAP

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
AUGUST 1990

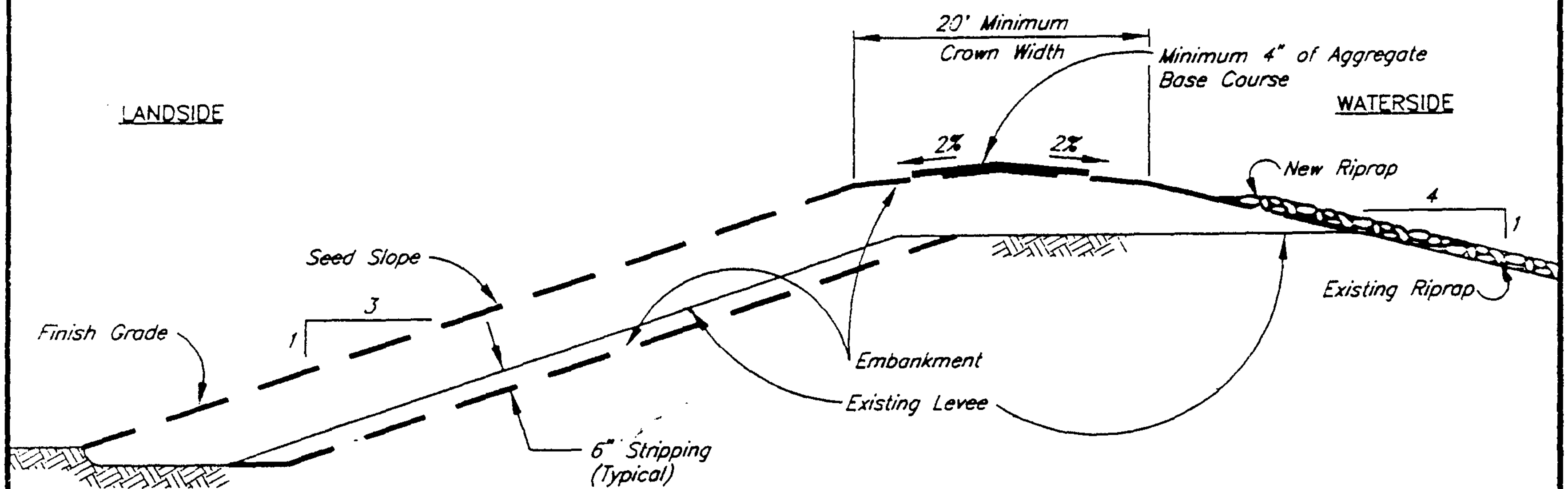
PLATE 1



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

RATING CURVES
SACRAMENTO RIVER
AT VERONA

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1988



STEP 1: Strip 6" (waste material).

STEP 2: Remove material, if necessary, from Landside slope so that fill can be placed on a minimum 8-foot wide bench (if satisfactory material is removed, it may be used for embankment fill).

STEP 3: Place embankment material to lines and grades indicated. Materials shall be compacted to a minimum 95% of maximum density determined by ASTM D 698 at ±3% of optimum moisture content.

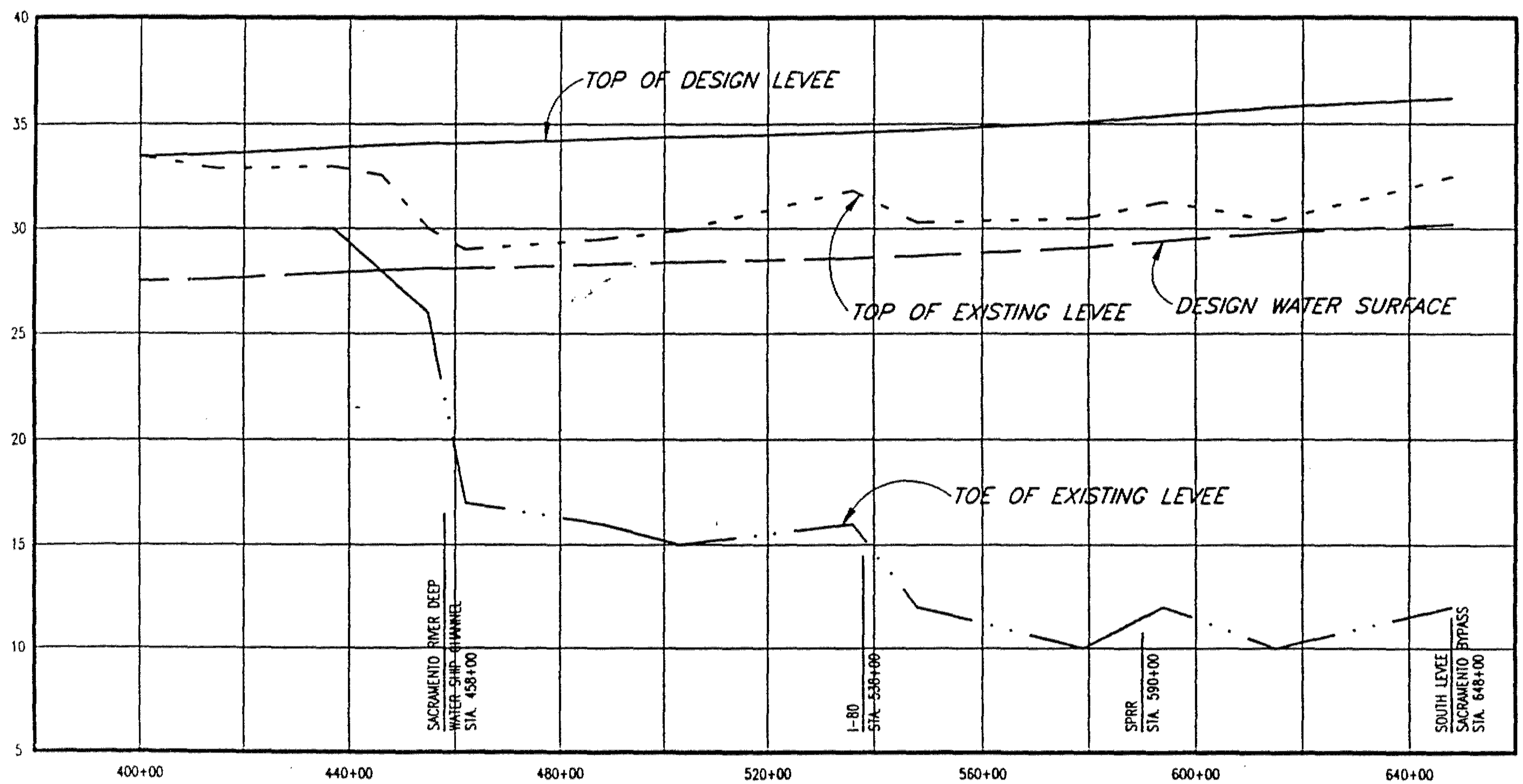
STEP 4: Place a minimum of 4 inches of aggregate base coursc for a 12-foot wide patrol road. Aggregate shall be compacted to a minimum of 100% of maximum density determined by ASTM D 698 at ±3% of optimum moisture content (crown width must be a minimum of 20 feet when construction is conpleted).

STEP 5: Place 12 inches of Riprap on new Waterside Slope.

STEP 6: Seed and establish grasses on new slopes, not ripraped, for erosion protection.

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

TYPICAL FILL LANDSIDE

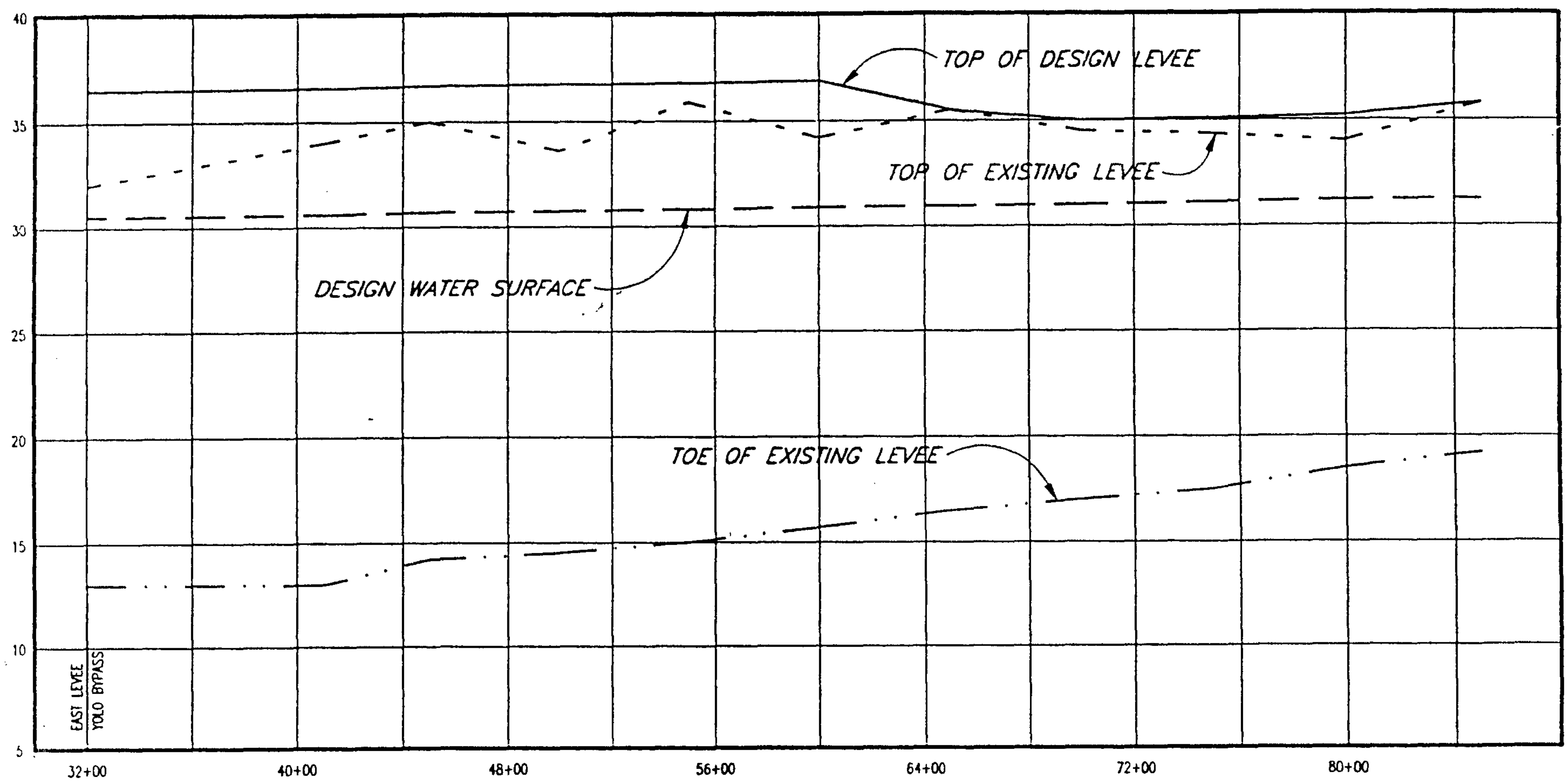


SACRAMENTO METROPOLITAN AREA
CALIFORNIA

LEVEE CROWN AND
WATER SURFACE PROFILES
YOLO BYPASS - EAST LEVEE
SELECTED PLAN

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
NOVEMBER 1990

PLATE 4



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

LEVEE CROWN AND
WATER SURFACE PROFILES
SACRAMENTO BYPASS - SOUTH LEVEE
SELECTED PLAN

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
NOVEMBER 1990

PLATE 5

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

APPENDIX D
ENGINEERING BASIS OF DESIGN AND COST ESTIMATES

ATTACHMENT 1

LEVEE FAILURE CRITERIA

SACRAMENTO METROPOLITAN AREA, CALIFORNIA
LEVEE FAILURE CRITERIA

This report describes the levee breaching scenario developed for the levees in the Sacramento Area. This scenario was based upon engineering studies and recommendations by different engineering disciplines as well as taking into account historical flood elevations and recent criteria to be used in determining breach elevations. One primary assumption used in this evaluation is that any levee repairs identified in the Sacramento River Flood Control System Evaluation have been completed.

Engineering analysis considered five major A/E and in-house levee stability studies. Other factors given weight in the engineering evaluation included wind and wave actions, flow velocities, duration of high stages, and erosion potential of the levee material. The existing conditions of the levees were also evaluated with respect to animal borings, cracks and homogeneity, and woody vegetation on or near levees. Additional information used in the analysis came from monitoring maintenance inspection records, determining locations of historical seepage and failure problems, experience from developing emergency repair plans, and levee performance under reoccurring flood stages. All of these factors were considered in developing an engineering determination of when levees might fail.

Further guidance on failure scenarios states that no levee should be assumed to fail if it has historically withstood higher elevations than might be indicated from a breaching scenario developed strictly from an engineering standpoint. Also, for existing levees, the initial failure scenario should consider encroachment into one-half the current design freeboard. Guidance suggests that after taking into account the engineering evaluations, the final scenario should reflect the historic elevation a levee has sustained or one-half freeboard encroachment, whichever is greater.

This guidance was applied to the levees surrounding West Sacramento. The critical reach of levee for West Sacramento is the Yolo Bypass East Levee from the Sacramento River Deep Water Ship Channel to the Sacramento Bypass. See Plate 1. This reach is plotted along with the different failure criteria and is shown on Figure 1. In this figure, the Breach Elevation profile represents the engineering evaluation, the 1/2 Freeboard profile is encroachment into one-half the existing freeboard, and the 1986 High Water Mark profile represents the historical high water elevation on the levee. Both the one-half freeboard and the 1986 water surface are higher than the engineering determined breach elevations. The Yolo Bypass levees were showing signs of distress during the 1986 flood. In addition, waves were wetting the top of the levees in several areas. This flood came close to the top of the levee in several reaches. Because of the distress exhibited during this flood, the 1986 high water was adopted as the final breach elevation. In the critical areas this is approximately two and one-half

feet from the top of the levee. Plate 1 shows where the levee could be expected to fail first.

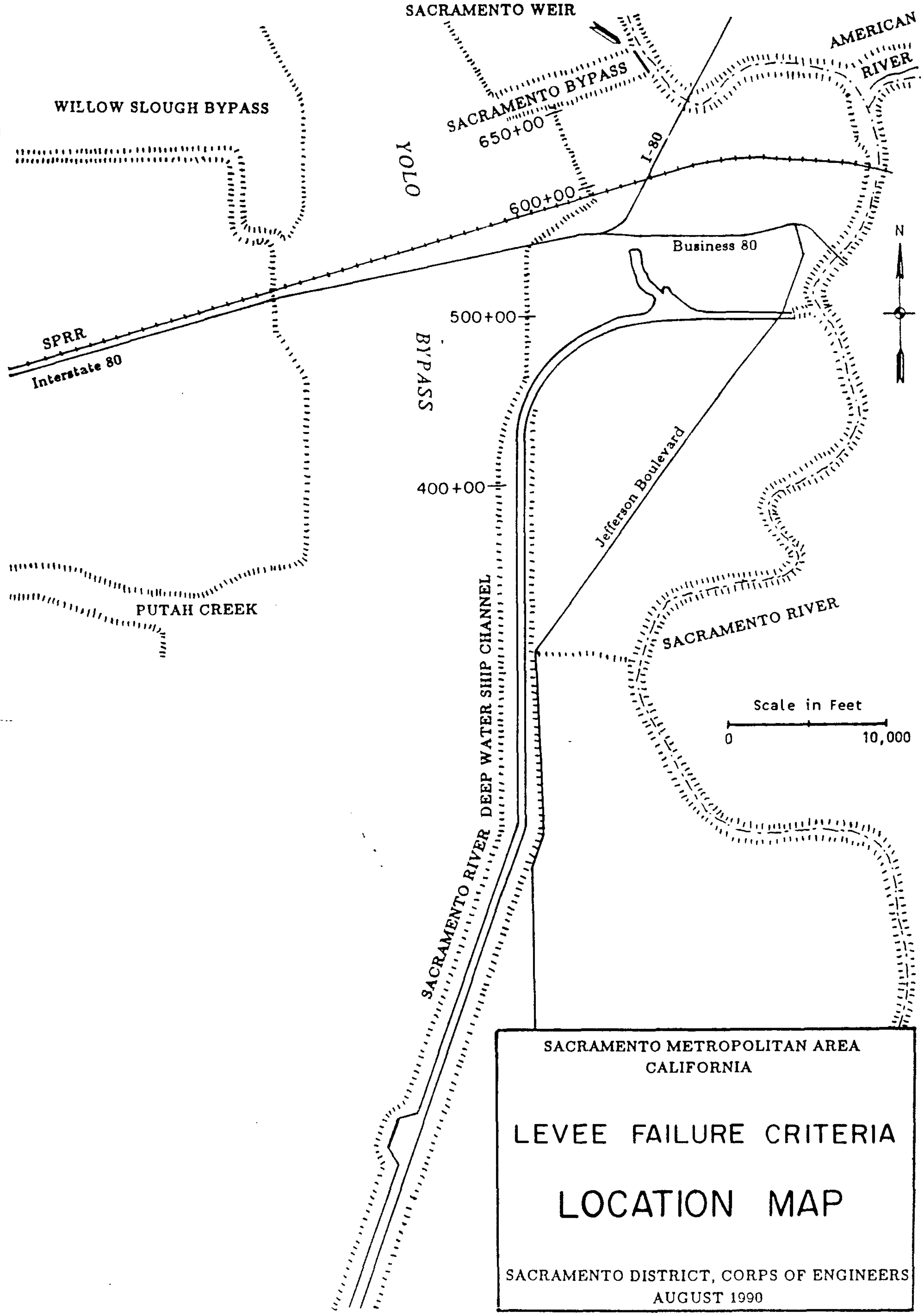
Table 1 gives the adopted flood encroachments to be used in determining breach elevations and frequencies for economic analysis.

The subjective nature of any levee failure scenario developed should be recognized. The development of a levee failure scenario is fraught with difficult technical considerations and economic, social and moral aspects that could jeopardize or bias the formulation of an acceptable project. The attempt has been to determine the most probably elevation at which failure would occur. These elevations represent information to be used for economic analysis only and should not be construed as absolute failure points for determining the flood safety of any of the areas under study.

TABLE 1

ADOPTED MINIMUM FREEBOARD ALLOWANCE FOR BREACHING SCENARIOS USED FOR ECONOMIC PURPOSES ONLY

Levee Reach	Minimum Freeboard (ft.)
1. RECLAMATION DISTRICT 1000	
a. Sacramento River (Left Bank) - Natomas Cross Canal to the Natomas East Main Drain	3
b. Natomas Cross Canal (North and South Levees)	2
c. Natomas East Main Drain - West Levee	1.5
2. AMERICAN RIVER LEVEE SYSTEM	
a. Right Bank, Sacramento River to River Mile 5.2	3
b. Right Bank, Upstream of River Mile 5.2	4
c. Left Bank, Sacramento River to River Mile 5.2	5
d. Left Bank, R.M. 5.2 to River Mile 7.8	5
e. Left Bank, Upstream of River Mile 7.8	4
3. DRY CREEK, ARCADE CREEK, AND THE EAST LEVEE OF THE NATOMAS EAST MAIN DRAIN	3
4. SACRAMENTO RIVER (LEFT BANK) FROM SACRAMENTO TO FREEPORT	3
5. SACRAMENTO RIVER (RIGHT BANK) FROM THE SACRAMENTO BYPASS TO RIVERVIEW	3
6. YOLO BYPASS	
a. East Side, South of Sacramento Bypass	2.5
b. All Other Yolo Bypass and Tributary Levees	3
7. SACRAMENTO RIVER (RIGHT BANK) FROM THE NATOMAS CROSS CANAL TO THE SACRAMENTO BYPASS	3



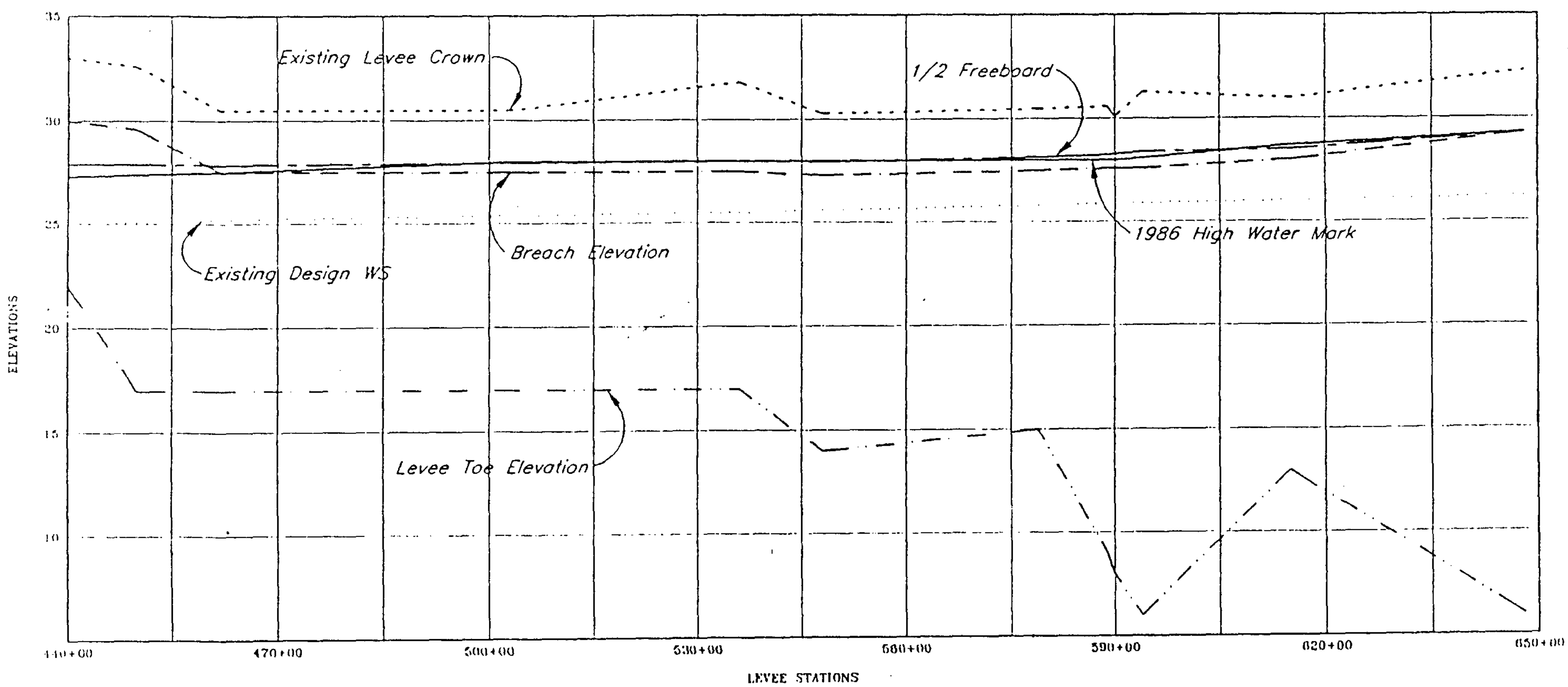
SACRAMENTO METROPOLITAN AREA
CALIFORNIA

LEVEE FAILURE CRITERIA

LOCATION MAP

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
AUGUST 1990

PLATE



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

YOLO BYPASS
EAST LEVEE

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
OCTOBER 1990

FIGURE 1

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

APPENDIX D
ENGINEERING BASIS OF DESIGN AND COST ESTIMATES

ATTACHMENT 2

HYDRAULIC IMPACTS OF THE SELECTED PLAN

Office Report
Sacramento Metropolitan Area, California
Hydraulic Impacts of the Selected Plan

Tables

Plates

Office Report
Sacramento Metropolitan Area, California
Hydraulic Impacts of the Selected Plan

Introduction

The purposes of this office report are to (1) discuss the impacts of the Selected Plan for the Sacramento Metropolitan Area, California, study on present levels of flooding in the study area, (2) indicate whether these impacts interfere with the present beneficial use of the land, and (3) determine if hydraulic mitigation measures are needed to offset any impacts.

Selected Plan

The Selected Plan that is identified in the February 1992 feasibility report includes raising and widening 5.7 miles of existing levee around West Sacramento along the east side of the Yolo Bypass and south side of Sacramento Bypass a maximum of 5.5 feet. Environmental mitigation measures are included to avoid, minimize or compensate for adverse environmental impacts of the levee raising. In addition, mitigation measures for all adjacent and downstream hydraulic impacts are included in the Selected Plan, regardless of the significance of such hydraulic impacts. (Plate 1 shows the original proposed levee raises.) The Selcted Plan would provide a 400-year level of flood protection to the West Sacramento area. At the same time, however, this levee raising could potentially impact adjacent and downstream areas by reducing hydraulic conveyance and flood storage. These impacts could result in slight increases in water surface elevations, duration of flooding and/or frequency of flooding. Fianl analysis for the February 1992 report showed an increase in water surface elevation of up to approximately 1 foot.

Evaluation of Hydraulic Impacts

Background. The existing levees and the flowage easement areas in the study area are part of the Sacramento River Flood Control System and are intended to manage flooding in the Yolo Bypass area. Any substantial increases in the existing depth, duration or frequency of flooding would require hydraulic mitigation to restore existing levels of flood protection or compensation to offset economic losses to landowners.

Hydraulic Analysis. The methodology used to determine the hydraulic impacts of the Selected Plan was a comparison of the depth, duration and frequency of flooding in the study area under without and with project conditions during the 100-, 200- or 400-year events. For both without and with project conditions, it was assumed that the American River Watershed Investigation Selected Plan (a 200-year flood control dam) and the Sacramento River Flood

Control System Evaluation, Phase I and II were in place. For this study, levee failure was assumed to occur when the water surface encroached to a point halfway into the design freeboard, or to the 1986 profile, whichever was higher. The design freeboard amounts for the various levee reaches were: 3 feet for the Sacramento River west levee; 6 feet for the Yolo Bypass west levee; 6 feet for the Sacramento Bypass south levee; 6 feet for the Yolo Bypass east levee from the Sacramento Bypass to the Ship Channel; and 4 feet for the Yolo Bypass east levee from the Ship Channel downstream. An analysis was done to determine the location and sequence of potential levee failures due to encroachment into the freeboard. Based on the assumption that the American River Watershed Investigation and the Sacramento River Flood Control Systems Evaluation, Phase I amd II, are in place, the four locations (in order of failure) would be: east levee of the Yolo Bypass just upstream of the Sacramento Bypass; east levee of the Yolo Bypass in the West Sacramento area; west levee of the Sacramento River just downstream of Verona; and west levee of the Sacramento River at River Mile 50.

Depth, duration and frequency of flooding are the parameters that were used to determine the hydraulic impacts. Depth is the average depth of water in the flood plain during the 100- , 200- or 400-year event. Duration refers to the average length of time that flood waters will remain on lands within the 100- , 200- or 400-year flood plain. For this report, frequency is the level of protection provided to a specific area under the without or with project condition.

The HEC-1 Flood Hydrograph Package and the DWOPER (Dynamic Wave Operational Model) computer program were used to route flows and determine maximum water-surface elevations for these frequencies at six areas along the Bypass. (Plate 2 shows the locations of the six areas.) These water-surface profiles were then used to determine the corresponding design levels of flood protection (see Table 1). Based on the results of this evaluation, five potentially affected areas were identified: Elkhorn Slough, North Willow Slough Bypass, South Willow Slough Bypass, Reclamation District (R.D.) 2068 and Lisbon/Flowage Easement. The water surface elevation for each of these areas increases slightly if the Selected Plan is constructed without the proposed hydraulic mitigation features. West Sacramento is the project area and does not have any areas requiring hydraulic mitigation.

Elkhorn Slough.

Without Project. - The Elkhorn Slough area extends from the Fremont Weir in the north to the Sacramento Bypass in the south. It is bounded on the west by the eastern levee of the Yolo Bypass and on the east by the Sacramento River. Land use is dominated by agriculture, primarily orchards, row crops and grains, and there are scattered farmsteads. Existing flooding of the

Table 1

Levels of Flood Protection under Without and With-Project Conditions

Location	Without Project		With Project		COMMENT
	Levels (ft msl)	Design Level of Prot.	Levels (ft msl)	Design Level of Prot.	
1 mile 12.6 Elkhorn Slough	A. 32.5 B. 29.0 C. 29.0 D. 29.4 E. 29.5 F. 26.4	20 yr	A. 32.5 B. 29.0 C. 29.7 D. 30.0 E. 30.3 F. 26.4	15 yr	American River Woodland curve #4, 2.6 feet below 1986 elevation
2 Mile 9.5 North Willow Slough Bypass	A. 33.7 B. 29.8 C. 30.1 D. 30.5 E. 30.7 F. 28.3	30 yr	A. 33.7 B. 29.8 C. 30.4 D. 31.1 E. 31.3 F. 28.3	25 yr	American River Woodland curve #4, 1.5 feet below 1986 elevation
3 Mile 15.7 South Willow Slough Bypass	A. 31.4 B. 27.1 C. 27.2 D. 27.3 E. 27.4 F. 25.4	30 yr	A. 31.4 B. 27.1 C. 27.7 D. 28.2 E. 28.3 F. 25.4	25 yr	American River Lisbon curve #4, 1.7 feet below 1986 elevation
4 Mile 28.4 R.D. 2068	A. 24.8 B. 20.8 C. 20.8 D. 20.3 E. 20.5 F. 20.6	50 yr	A. 24.8 B. 20.8 C. 20.9 D. 21.3 E. 21.6 F. 20.3	50 yr	American River Lisbon curve #4, .5 feet below 1986 elevation
5 Lisbon/ Flowage Easement	A. N/A B. N/A C. 25.1 D. 25.2 E. 25.3 F. 23.7	35 yr	A. N/A B. N/A C. 25.3 D. 25.7 E. 25.8 F. 23.7	35 yr	American River Lisbon curve #4
6 Mile 13.4 West Sacramento	A. 30.4 B. 28.4 C. 28.3 D. 28.4 E. 28.6 F. 26.0	20 yr	A. 30.4 B. 28.4 C. 28.8 D. 29.3 E. 29.5 F. 26.0	400 yr	American River Lisbon curve #4, 2.4 feet below 1986 elevation

NOTES:
A - Levee Crown elevation
B - 1986 elevation
C - 100 year elevation
D - 200 year elevation
E - 400 year elevation
F.- Design Water Surface Elevation

Area 4 elevations from DLY510BD
Curves used were plotted from data in runs DXY510BC, DXY520BC,DXY540BC

Elkhorn Slough area may occur either by failure of the left bank of the Yolo Bypass levee from the west or failure of the right bank of the Sacramento River levee from the north and east. Once failure occurs, the area would fill to a level of flood elevation with average depths of about 14 feet for a 400-year event. This depth was based on the difference in estimated floodplain water surface elevation and ground elevation. The potential area of impact is the southern portion of Elkhorn near the Sacramento Bypass.

With Project. - Tables 2 and 3 show the estimated average depths and durations of flooding under without and with project conditions at the Elkhorn Slough area. The data indicate that there would be minor increases in the depth or duration of flooding in the area under with project conditions.

Table 2
Estimated Average Depths of Flooding in the Elkhorn Slough Area

Flood Event	Without Project	With Project
100-Year	14.0 feet	14.7 feet
200-Year	14.4 feet	15.0 feet
400-Year	14.5 feet	15.3 feet

Table 3
Estimated Durations of Flooding in the Elkhorn Slough Area

Flood Event	Without Project	With Project
100-Year	3 days	3.5 days
200-Year	4 days	4.5 days
400-Year	4 days	5.0 days

North Willow Slough Bypass.

Without Project. - The Willow Slough Bypass is a manmade channel located south of Willow Slough and north of South Fork Putah Creek. The bypass was constructed to route floodflows from Willow Slough to the Yolo Bypass. Land use in the area is dominated by agriculture, and the Willow Slough Bypass also serves as an agricultural drain and an agricultural water supply for rice. Existing flooding of the area may result from failure of either of the Willow Slough Bypass levees, failure of the Yolo Bypass levee, and/or backwater effects from the Yolo Bypass. Flooding from the Yolo Bypass would be much deeper and would cover a greater area than the flooding from the Willow Slough Bypass. Average flood

depths for a 400-year event in the Yolo Bypass would range from 7.1 to 7.7 feet, depending on the location. The potential area of impact is north of the Willow Slough Bypass and west of the Yolo Bypass levee.

With Project. - Tables 4 and 5 show the estimated average depths and durations of flooding under without and with project conditions at the North Willow Slough Bypass area. The data indicate that there would be minor increases in the depth or duration of flooding in the area under with project conditions.

Table 4
Estimated Average Depths of Flooding in the North Willow Slough Bypass Area

Flood Event	Without Project	With Project
100-Year	7.1 feet	7.4 feet
200-Year	7.5 feet	8.1 feet
400-Year	7.7 feet	8.3 feet

Table 5
Estimated Durations of Flooding in the North Willow Slough Bypass Area

Flood Event	Without Project	With Project
100-Year	3 days	3.5 days
200-Year	4 days	4.5 days
400-Year	4 days	5.0 days

South Willow Slough Bypass.

Without Project. - Similar to the North Willow Slough Bypass, land use in the area is dominated by agriculture. Existing flooding in the area would be the same as for the North Willow Slough Bypass area. The potential area of impact is south of the Willow Slough Bypass, west of the Yolo Bypass levee and north of the Southern Pacific Railroad (SPRR) tracks. (It is assumed that flood waters would not breach the SPRR embankment.)

With Project. - Tables 6 and 7 show the estimated average depths and durations of flooding under without and with project conditions at the South Willow Slough Bypass area. The data indicate that there would be minor increases in the depth or duration of flooding in the area under with project conditions.

Table 6
Estimated Average Depths of Flooding in the South Willow Slough Bypass Area

Flood Event	Without Project	With Project
100-Year	7.2 feet	7.7 feet
200-Year	7.3 feet	8.2 feet
400-Year	7.4 feet	8.3 feet

Table 7
Estimated Durations of Flooding in the South Willow Slough Bypass Area

Flood Event	Without Project	With Project
100-Year	3 days	3.5 days
200-Year	4 days	4.5 days
400-Year	4 days	5.0 days

R.D. 2068.

Without Project. - Land use in the area is dominated by agriculture. Existing flooding in the area results from overflow from Cache Slough, located south of the existing levee. Water surface elevations reach a maximum of about 17 feet, thereby resulting in average flooding depths of 5.5 feet. Flows from the Yolo Bypass would cause additional sheet flow flooding near the northern end of the existing levee.

With Project. - Tables 8 and 9 show the estimated average depths and durations of flooding under without and with project conditions at the R.D. 2068 site. The data indicate that under project conditions there would be a maximum increase of about 1 foot in the depth or duration of flooding in the agricultural areas southwest of the existing levee.

Table 8
Estimated Average Depths of Flooding in the R.D. 2068 Area

Flood Event	Without Project	With Project
100-Year	5.8 feet	5.9 feet
200-Year	5.3 feet	6.3 feet
400-Year	5.5 feet	6.6 feet

Table 9
Estimated Durations of Flooding in the R.D. 2068 Area

Flood Event	Without Project	With Project
100-Year	3 days	3.5 days
200-Year	4 days	4.5 days
400-Year	4 days	5.0 days

Lisbon/Flowage Easement Area.

Without Project. - The Lisbon/Easement area extends from just south of Putah Creek to an area about 4 miles south of Freeport. The Yolo Bypass west levee is discontinuous in this area. Land use in this area is dominated by agriculture, and an occasional residence has been built in or near the area presently subject to flooding. The flooded area resulting from any given flood event is related to the existing ground surface elevation and the volume of flow being carried by the system in the reach. Existing flowage easements within the Bypass contain no limitations on depth, duration or frequency of flooding. Plate 3 shows the existing flowage easement areas and the extent of flooding under the 100- and 400-year events under without and with project conditions.

With Project. - Tables 8 and 9 show the estimated elevations and duration of flooding under without and with project conditions at the Lisbon/Flowage Easement area. According to Table 10, the increase in elevation of flooding due to implementation of the Selected Plan is only 0.3 foot for the 100-year flood. The data also indicate that there would be minor increases in the duration or level of flood protection in the area under with project conditions.

Table 10
Estimated Elevations of Flooding in the Lisbon/Flowage Easement Area

Flood Event	Without Project	With Project
100-Year	25.1 feet	25.4 feet
200-Year	25.2 feet	25.6 feet
400-Year	25.3 feet	25.7 feet

Table 11
Estimated Durations of Flooding in the Lisbon/Flowage Easement Area

Flood Event	Without Project	With Project
100-Year	3 days	3.5 days
200-Year	4 days	4.5 days
400-Year	4 days	5.0 days

Economic Analysis

An economic analysis was completed to determine the benefits and costs of mitigating for the hydraulic impacts in the areas. In accordance with planning guidance for determining flood damage prevention benefits in the freeboard range, benefits can be claimed for one-half of the area under the frequency-damage curve between the design level of protection and the largest flood that might be carried within the freeboard. Due to hydraulic assumptions upstream of the study area, no appreciable flow enters the Yolo Bypass beyond the 400-year flood event. Therefore, the 400-year flood would essentially be the maximum event possible in the study area. Cost estimates were based on the additional levee construction necessary to maintain the level of flood protection under without project conditions. Equivalent average annual benefits include some benefits within the freeboard range. Benefits and costs are shown on Table 12.

Benefit estimates for Elkhorn Slough, North and South Willow Slough Bypass and R.D. 2068 reflected the minimal increases in flood damages under with project conditions. The acquisition of flowage easements area is based on project operation rather than providing flood protection. In essence, easements are compensation for future flood damages, and benefit and benefit-to-cost analyses are usually not done. However, average annual costs to acquire the easements were determined.

Table 12
Summary of Economic Analysis of Hydraulic Mitigation

Area	Avg Annual Damages	Avg Annual Benefits	Avg Annual Costs	B/C
Elkhorn Slough	$54,200	$44,950	$225,000	.20
North Willow Slough Bypass	$17,000	$13,170	$225,000	.06
South Willow Slough Bypass	$14,850	$11,470	$255,000	.04
R.D. 2068 1/	1/	1/	$ 40,000	
Lisbon/Flowage Easement 2/	2/	2/	$360,000	

1/ To be developed.
2/ See discussion in preceding paragraph.

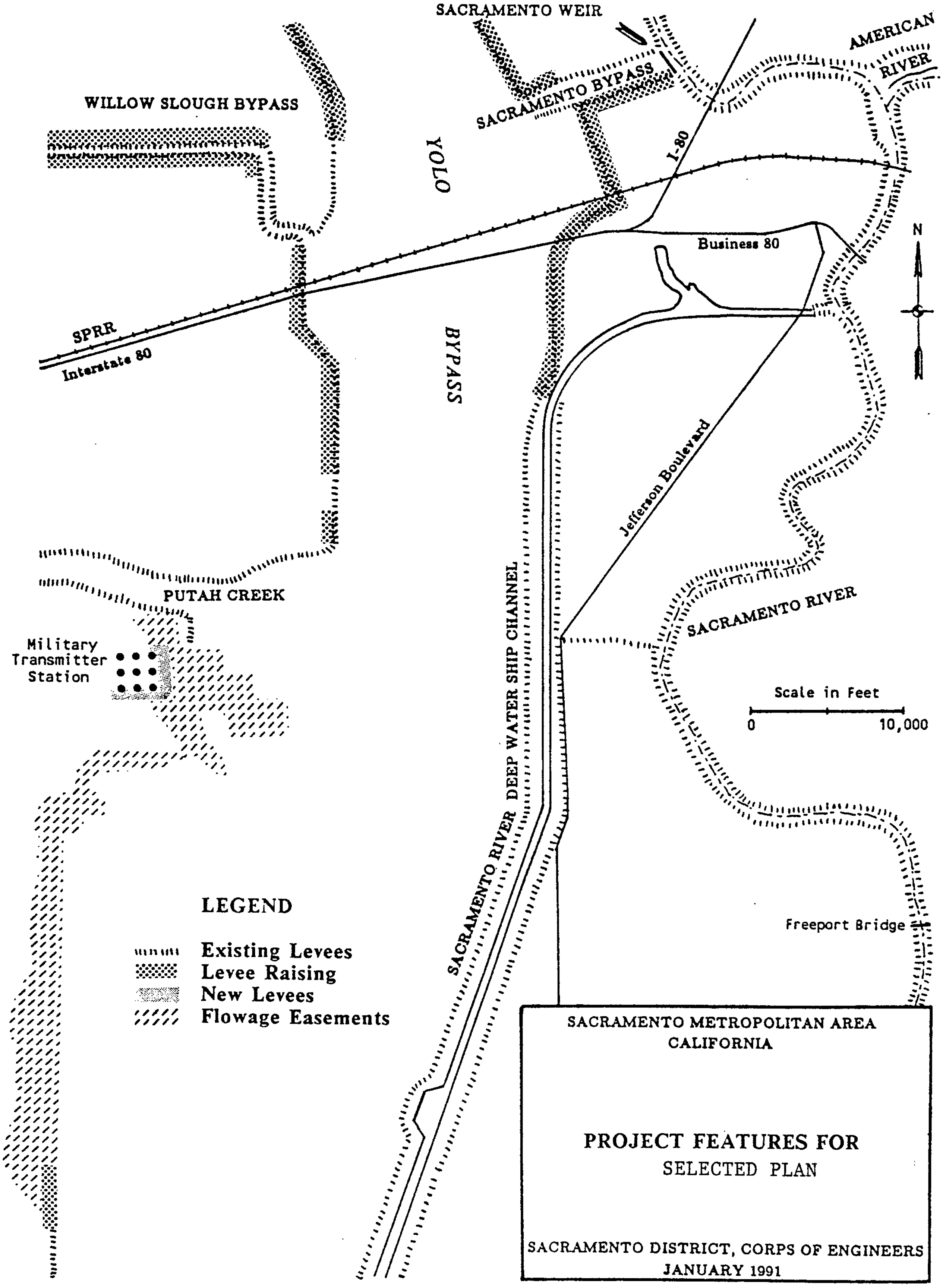
Real Estate Evaluation

An evaluation was made to determine the effects (if any) of the hydraulic impacts on the present beneficial use or value of the affected lands. Generally, a "taking" occurs when there is either a physical appropriation of property or a substantial interference with it which destroys or lessens its value. There must be a substantial interference with the elemental rights growing out of ownership of the property (Harris v. United States, 467 F. 2d 801). The degree of interference is necessary to constitute a "taking" is not subject to exacting guidelines; however, it must be substantial and approach the deprivation of all beneficial use.

The results of the evaluation indicated that implementation of the Selected Plan would not substantially affect the present beneficial use or value of the impacted lands. Hydraulic analyses show that there are only minor increases in the depth, duration or frequency of flooding over that which already occurs during the 100- , 200- or 400-year flood events. The land is used primarily for agriculture, and small changes in flooding would not have an appreciable effect on the beneficial use or value.

Summary

Analysis indicates that impacts to depth, duration or frequency of flooding are minor and do not create an additional flood hazard or interfere with the present beneficial use of the land. Therefore, hydraulic mitigation measures were not need to be included as part of the Sacramento Metropolitan Area Investigation.



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

PROJECT FEATURES FOR
SELECTED PLAN

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1991

PLATE 1

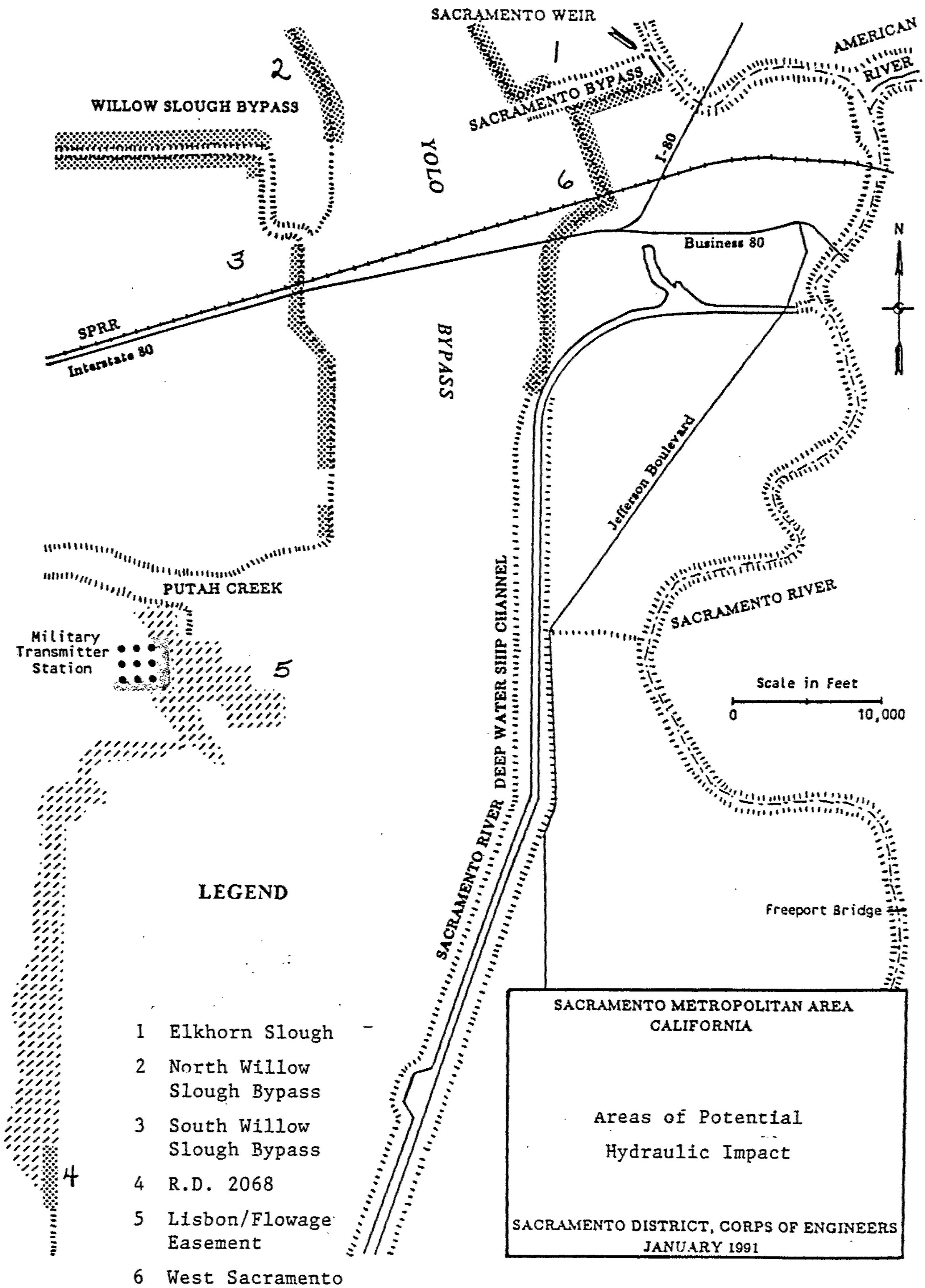

SACRAMENTO WEIR
AMERICAN RIVER
SACRAMENTO BYPASS
WILLOW SLOUGH BYPASS
YOLO BYPASS
I-80
Business 80
SPRR
Interstate 80
N
Jefferson Boulevard
PUTAH CREEK
Military Transmitter Station
SACRAMENTO RIVER DEEP WATER SHIP CHANNEL
SACRAMENTO RIVER
Scale in Feet
0
10,000
Freeport Bridge
1
2
3
4
5
6
LEGEND
1 Elkhorn Slough
2 North Willow Slough Bypass
3 South Willow Slough Bypass
4 R.D. 2068
5 Lisbon/Flowage Easement
6 West Sacramento
SACRAMENTO METROPOLITAN AREA
CALIFORNIA
Areas of Potential
Hydraulic Impact
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1991

PLATE 2

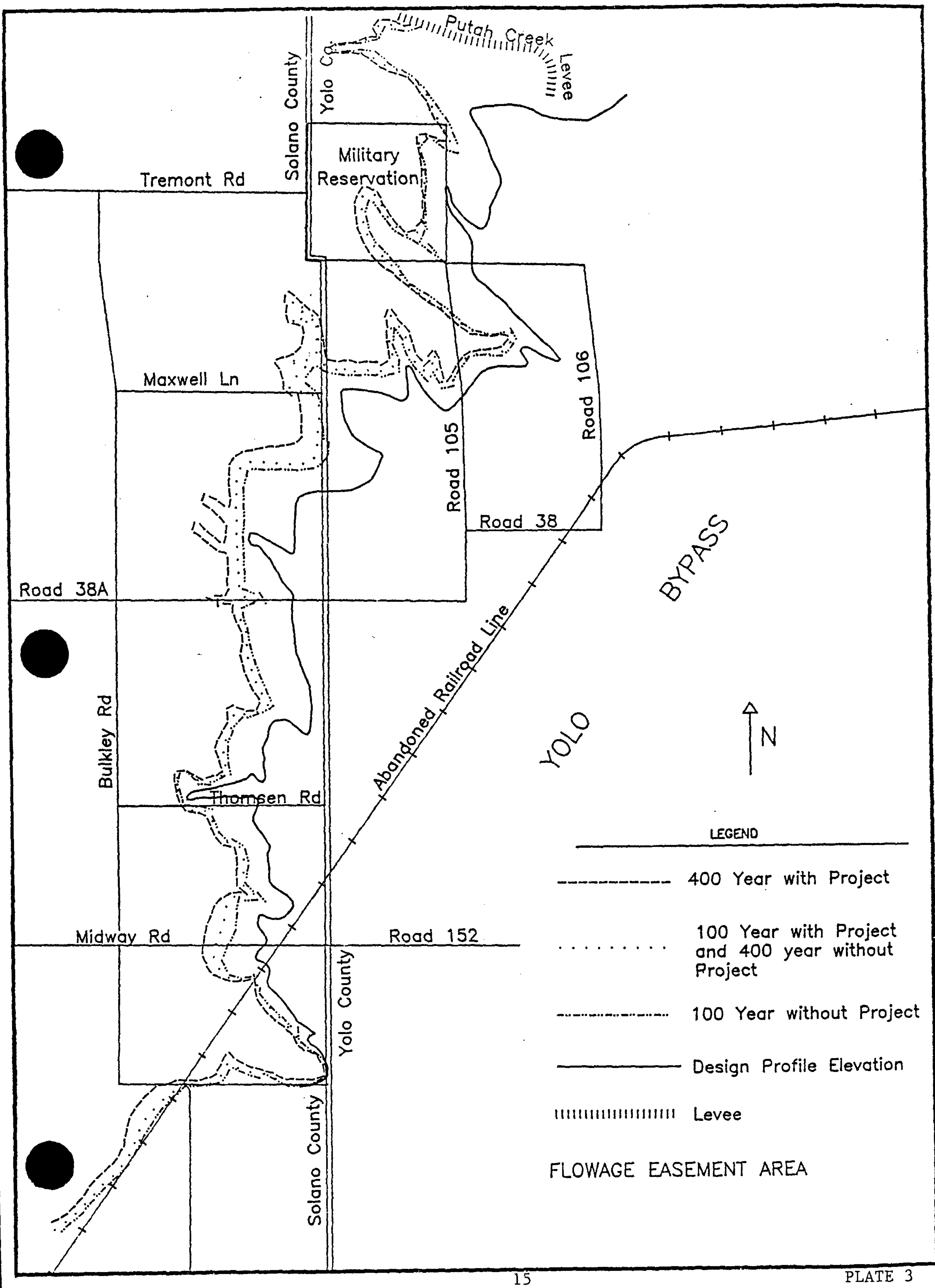

Putah Creek Levee
Solano County
Yolo Co
Military Reservation
Tremont Rd
Maxwell Ln
Road 106
Road 105
Road 38
Road 38A
BYPASS
YOLO
Abandoned Railroad Line
N
Bulkley Rd
Thomsen Rd
Midway Rd
Road 152
Yolo County
Solano County
LEGEND
400 Year with Project
100 Year with Project and 400 year without Project
100 Year without Project
Design Profile Elevation
Levee
FLOWAGE EASEMENT AREA

PLATE 3

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

APPENDIX D
ENGINEERING BASIS OF DESIGN AND COST ESTIMATES

ATTACHMENT 3

M-CACES COST ESTIMATE FOR THE SELECTED PLAN

COST ESTIMATE

SACRAMENTO METROPOLITAN AREA
CALIFORNIA

FEASIBILITY REPORT
SELECTED (NED) PLAN

COST ESTIMATE

==

To the best of my knowledge the cost estimate was prepared in full compliance with EC 1110-2-263 dated 28 February 1989 and EC 1110-2-538 dated 28 February 1989. Both Engineer Circulars expiration dates have been extended by Civil Works Cost Estimating Guidance Update dated 23 February 1990. The fully funded cost estimate was prepared in full compliance with EC 11-2-157 published in March 1990.

Harvey T. Louis ____________________ Dated: 13 Jan 1992
Harvey T Louis
Cost Estimator

Andrew M. Abrate ____________________ Dated: 14 Jan 1992
Andrew M. Abrate
Chief, Cost Engineering Branch

Lewis A. Whitney ____________________ Dated: 14 Jan 1992
Lewis A. Whitney
Chief, Engineering Division

____________________ Dated: 15 Jan 1992
Bob Childs
Life Cycle Project Manager

John P. Saia ____________________ Dated : 15 Jan 1992
John P. Saia
Chair, Project Review Board

PROJECT COST ESTIMATE

SELECTED PLAN

ITEM	DESCRIPTION	COST
01	LANDS AND DAMAGES	$ 1,880,000
02	RELOCATIONS	15,000
06	FISH AND WILDLIFE FACILITIES	2,400,000
11	LEVEES	10,200,000
18	CULTURAL RESOURCE PRESERVATION	131,000
30	PLANNING, ENGINEERING, AND DESIGN	1,665,000
31	CONSTRUCTION MANAGEMENT	1,132,000
	TOTAL PROJECT COST	17,423,000

COST ESTIMATE

1. **TOTAL PROJECT COST SUMMARIES.** - The total project cost summaries fully funded to the mid-point of construction are shown in Table 1. The cost is based on October 1, 1991 price level. The apportionment of Federal and Non-Federal first costs is based on the criteria contained in the Water Resources Development Act of 1986.

2. **BASIS OF FIRST COST.** - The detailed estimate of the project first cost with contingencies detailed is shown in Table 2. The estimate is based on the following.

a. Lands. - The land costs were provided by the Sacramento District Real Estate Division. The non-federal sponsor provided their estimate of labor costs.

b. Wildlife facilities and sanctuaries. - Construction costs were provided by the Sacramento District Environmental Resources Branch and is based on experience to date with other similar revegetation work.

c. Levees. - Construction is based on awarding one contract. The unit prices used were developed using the M-CACES EDITION of COMPOSER Gold and experience to date on similar projects. An estimate of how the major construction is to be accomplished is as follows.

Cleared and grubbed vegetation will be removed and pushed aside for on site burning. Stripped material will be hauled an average of 20 miles to a waste area. Excavated material that will be reused on site can be stockpiled nearby for later final disposition. The material for the levee embankment will be excavated from borrow with an average haul distance of 20 miles. Excavation will be by dozer and front end loaders and hauling by truck. The material will be placed and compacted using dozers with sheepsfoot rollers and water trucks. The levee patrol road surfacing will be done using conventional road surfacing methods and equipment.

Materials required will be obtained from local sources. Material prices are based on corresponding current bid unit prices recieved on comparable work in the area.

Concrete construction is normal concrete work (formwork, placing reinforcement and concrete, and finishing). Concrete is available locally. Delivery is by truck and placement by pump.

d. PED and Construction Management. - Pricing data for design and inspection was provided by the Sacramento District Design and Construction branches and is based on experience to date on similar projects in the Sacramento District.

TABLE 1

TOTAL - ALL CONTRACTS **** TOTAL PROJECT COST SUMMARIES ****

PROJECT: SACRAMENTO METROPOLITAN AREA PREPARED BY: SACRAMENTO DISTRICT
LOCATION: CALIFORNIA
DATE PREPARED: 29-Aug-91 Effective Price Date(EPD) 1 Oct-91 REVIEWED & APPROVED BY: ANDY ABRATE BRANCH CHIEF

ACCOUNT NUMBER	ITEM DESCRIPTION	COST (EPD) ($)	CONTING. AMOUNT ($) *		TOTAL EST EST (EPD) ($) *	INFLATED COST AMOUNT ($) *	INFLATED CONTG. AMT. ($) *	FULLY FUNDED COST ($) *
			* (Figures Rounded)					\1
	FEDERAL COSTS							
06---	**FISH & WILDLIFE FACILITIES**	**2,095,000**	**305,000**	**15%**	**2,400,000**	**2,533,000**	**367,000**	**2,900,000**
11---	**LEVEES AND FLOODWALLS**	**8,371,770**	**1,828,230**	**22%**	**10,200,000**	**10,057,000**	**2,193,000**	**12,250,000**
	Construction Costs	10,466,770	2,133,230		12,600,000	12,590,000	2,560,000	15,150,000
01---	**LANDS AND DAMAGES \2**	**150,525**	**29,475**	**20%**	**180,000**	**175,000**	**35,000**	**210,000**
18---	**CULTURAL RESOURCES PRES.\3**	**98,000**	**33,000**	**34%**	**131,000**	**120,000**	**40,000**	**160,000**
30---	**PLANNING, ENGR. & DESIGN**	**1,291,100**	**368,900**	**29%**	**1,660,000**	**1,516,000**	**434,000**	**1,950,000**
31---	**CONSTRUCTION MANAGEMENT**	**860,000**	**270,000**	**31%**	**1,130,000**	**1,180,000**	**370,000**	**1,550,000**
SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION		12,866,395	2,834,605	22%	15,701,000	15,581,000	3,439,000	19,020,000
NON-FEDERAL CASH CONTRIBUTION		2,168,000	433,000	20%	2,601,000	2,677,000	543,000	3,220,000
TOTAL FEDERAL COSTS		**10,698,395**	**2,401,605**	**22%**	**13,100,000**	**12,904,000**	**2,896,000**	**15,800,000**
	NON-FEDERAL COSTS							
	Construction Costs							
02---	**RELOCATIONS**	**14,000**	**1,000**	**7%**	**15,000**	**19,000**	**1,000**	**20,000**
01---	**LANDS AND DAMAGES**	**1,345,595**	**354,405**	**26%**	**1,700,000**	**1,544,000**	**406,000**	**1,950,000**
30---	**PLANNING, ENGR. & DESIGN**	**4,000**	**1,000**	**25%**	**5,000**	**6,000**	**1,000**	**7,000**
31---	**CONSTRUCTION MANAGEMENT**	**1,500**	**500**	**33%**	**2,000**	**2,000**	**1,000**	**3,000**
SUBTOTAL NON-FEDERAL		1,365,095	356,905	26%	1,722,000	1,571,000	409,000	1,980,000
NON-FEDERAL CASH CONTRIBUTION		2,168,000	433,000	20%	2,601,000	2,677,000	543,000	3,220,000
TOTAL NON-FEDERAL COSTS		**3,533,095**	**789,905**	**22%**	**4,323,000**	**4,248,000**	**952,000**	**5,200,000**
TOTAL FEDERAL AND NON-FEDERAL COSTS		**14,231,490**	**3,191,510**	**22%**	**17,423,000**	**17,152,000**	**3,848,000**	**21,000,000**

\1. The fully funded cost estimate was prepared in compliance with EC 11-8-2 (FR) published in March 1991.
\2. Federal administrative costs for non-Federal land acquisition.
\3. Cultural Resources Preservation costs associated with mitigation and/or data recovery up to one percent of the total Federal cost are not subject to cost sharing.

TABLE 1

PROJECT: SACRAMENTO METROPOLITAN AREA PREPARED BY: SACRAMENTO DISTRICT
LOCATION: CALIFORNIA
DATE PREPARED: 29-Aug-91 Effective Price Date(EPD) 1 Oct-91 REVIEWED & APPROVED BY: ANDY ABRATE BRANCH CHIEF

ACCOUNT NUMBER	ITEM DESCRIPTION	COST (EPD) ($)	CONTING. AMOUNT ($) *	%	TOTAL EST EST (EPD) ($) *	MID PT OF CONST	OMB INFL. (+/-)	INFLATED COST AMOUNT ($) *	INFLATED CONTG. AMT. ($) *	FULLY FUNDED COST ($) *
			* (Figures Rounded)							\1
	FEDERAL COSTS									
06---	**FISH & WILDLIFE FACILITIES**	**2,095,000**	**305,000**	**15%**	**2,400,000**	**OCT 96**	**20.8%**	**2,533,000**	**367,000**	**2,900,000**
3--	WILDLIFE FACILITIES & SANCTUARIES	2,095,000	305,000	15%	2,400,000	OCT 96	20.8%	2,533,000	367,000	2,900,000
11---	**LEVEES AND FLOODWALLS**	**8,371,770**	**1,828,230**	**22%**	**10,200,000**	**OCT 96**	**20.1%**	**10,057,000**	**2,193,000**	**12,250,000**
	Construction Costs	10,466,770	2,133,230	20%	12,600,000			12,590,000	2,560,000	15,150,000
01---	**LANDS AND DAMAGES \2**	**150,525**	**29,475**	**20%**	**180,000**		**16.7%**	**175,000**	**35,000**	**210,000**
30---	**PLANNING, ENGR. & DESIGN**	**1,291,100**	**368,900**	**29%**	**1,660,000**		**17.5%**	**1,516,000**	**434,000**	**1,950,000**
31---	**CONSTRUCTION MANAGEMENT**	**860,000**	**270,000**	**31%**	**1,130,000**		**37.2%**	**1,180,000**	**370,000**	**1,550,000**
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION	12,768,395	2,801,605	22%	15,570,000			15,461,000	3,399,000	18,860,000
	NON-FEDERAL CASH CONTRIBUTION	2,168,000	433,000	20%	2,601,000			2,677,000	543,000	3,220,000
	TOTAL FEDERAL COSTS	**10,600,395**	**2,368,605**	**22%**	**12,969,000**			**12,784,000**	**2,856,000**	**15,640,000**
	NON-FEDERAL COSTS									
	Construction Costs									
02---	**RELOCATIONS**	**14,000**	**1,000**	**7%**	**15,000**		**33.3%**	**19,000**	**1,000**	**20,000**
3--	CEMETERIES, UTILITIES & STRUCTURES	14,000	1,000	7%	15,000		33.3%	19,000	1,000	20,000
01---	**LANDS AND DAMAGES**	**1,345,595**	**354,405**	**26%**	**1,700,000**		**14.7%**	**1,544,000**	**406,000**	**1,950,000**
30---	**PLANNING, ENGR. & DESIGN**	**4,000**	**1,000**	**25%**	**5,000**		**40.0%**	**6,000**	**1,000**	**7,000**
31---	**CONSTRUCTION MANAGEMENT**	**1,500**	**500**	**33%**	**2,000**		**50.0%**	**2,000**	**1,000**	**3,000**
	SUBTOTAL NON-FEDERAL	1,365,095	356,905	26%	1,722,000			1,571,000	409,000	1,980,000
	NON-FEDERAL CASH CONTRIBUTION	2,168,000	433,000	20%	2,601,000			2,677,000	543,000	3,220,000
	TOTAL NON-FEDERAL COSTS	**3,533,095**	**789,905**	**22%**	**4,323,000**			**4,248,000**	**952,000**	**5,200,000**
	TOTAL FEDERAL AND NON-FEDERAL COSTS	**14,133,490**	**3,158,510**	**22%**	**17,292,000**			**17,032,000**	**3,808,000**	**20,840,000**

\1. The fully funded cost estimate was prepared in compliance with EC 11-8-2 (FR) published in March 1991.
\2. Federal administrative costs for non-Federal land acquisition.

TABLE 1

PROJECT: SACRAMENTO METROPOLITAN AREA
LOCATION: CALIFORNIA
DATE PREPARED: 29-Aug-91 Effective Price Date(EPD) 1 Oct-91

PREPARED BY: SACRAMENTO DISTRICT
REVIEWED & APPROVED BY: ANDY ABRATE BRANCH CHIEF

ACCOUNT NUMBER	ITEM DESCRIPTION	COST (EPD) ($)	CONTING. AMOUNT ($) *	%	TOTAL EST EST (EPD) ($) *	MID PT OF CONST	OMB INFL. (+/-)	INFLATED COST AMOUNT ($) *	INFLATED CONTG. AMT. ($) *	FULLY FUNDED COST ($) * \1
	FEDERAL COSTS									
18---	CULTURAL RESOURCE PRES.\2	98,000	33,000	34%	131,000	APR 97	22.1%	120,000	40,000	160,000
	TOTAL FEDERAL COSTS	98,000	33,000	34%	131,000			120,000	40,000	160,000
	NON-FEDERAL COSTS									
	NONE									

* (Figures Rounded)

\1. The fully funded cost estimate was prepared in compliance with EC 11-8-2 (FR) published in March 1991.
\2. Cultural Resources Preservation costs associated with mitigation and/or data recovery up to one percent of the total Federal cost are not subject to cost sharing.

COST ESTIMATE

DETAILED ESTIMATE OF FIRST COST **TABLE 2**

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE $	AMOUNT $	CONTINGENCY $ *	CONTINGENCY % *	REASON
	Price Level as of 1 Oct-91					*** (Figures Rounded)**		
	FEDERAL							
01.-.-.-	**LANDS AND DAMAGES**							
01.A.-.-	PRE-AUTHORIZATION PLANNING							
01.A.2.-	Develop Acquisiton Schedule	3	MD	430.00	1,290			
01.A.3.-	Real estate design Memorandum	10	MD	430.00	4,300			
01.A.8.-	All Other	31	MD	475.00	14,725			
01.A.9.-	Contingencies	1	JOB	LS		3,000		
01.B.-.-	POST-AUTHORIZATION PLANNING							
01.B.1.-	Develop Cost Estimate	50	MD	410.00	20,500			
01.B.3.-	Real estate design Memorandum	15	MD	425.00	6,375			
01.B.4.-	Evaluate Sponsor Capability	5	MD	440.00	2,200			
01.B.8.-	All Other	93	MD	400.00	37,200			
01.B.9.-	Contingencies	1	JOB	LS		12,300		
01.C.-.-	LOCAL COOPERATION AGREEMENT							
01.C.1.-	Draft LCA	5	MD	440.00	2,200			
01.C.2.-	Final LCA	2	MD	450.00	900			
01.C.9.-	Contingencies	1	JOB	LS		600		
01.D.-.-	ACQUISITIONS							
01.D.1.-	Attorney's Opinion							
01.D.1.D	Prepare Documents	5	MD	440.00	2,200			
01.D.2.-	Mapping, Survey and Tract Ownership							
01.D.2.D	Prepare Documents	5	MD	350.00	1,750			
01.D.2.Z	All Other	17	MD	350.00	5,950			
01.D.4.-	Negotiations and Closing							
01.D.4.F	Review for Compliance	23	MD	370.00	8,510			
01.D.4.Z	All Other	65	MD	425.00	27,625	7,000	25.3	
01.F.-.-	APPRAISALS							
01.F.1.-	Staff Appraisals							
01.F.1.Z	All Other	2	MD	450.00	900			
01.F.2.-	Contract Appraisals							
01.F.2.Z	All Other	26	MD	450.00	11,700			
01.F.9.-	Contingencies	1	JOB	LS		1,900		
01.K.-.-	TEMPORARY PERMITS							
01.K.0.D	Prepare Documents	5	MD	440.00	2,200			
01.K.9.-	Contingencies	1	JOB	LS		400		
	Subtotal, Construction Costs:			$	150,525			
	Contingencies @ average of	19.6 % +/- *			$	29,475		(a)
01.-.-.-	**LANDS AND DAMAGES**			**TOTAL:**	**$**	**180,000**		

COST ESTIMATE

DETAILED ESTIMATE OF FIRST COST

TABLE 2

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE $	COST $	CONTINGENCY $ *	CONTINGENCY % *	REASON
	Price Level as of 1 Oct-91					*** (Figures Rounded)**		
	FEDERAL							
06.3.-.-	**WILDLIFE FACILITIES AND SANCTUARIES**							
06.3.B.-	Habitat and Feeding Facilities:							
06.3.3.B	Site Work							
	Riparian Forest Planting	50	Acre	25,000.00	1,250,000	187,500	15.0	(2)
	Marsh Excavation to waste 20 mi	150,000	CY	5.30	795,000	119,250	15.0	(2)
	Marsh Revegetation	10	Acre	5,000.00	50,000	7,500	15.0	(2)
	Subtotal, Construction Costs:			$	2,095,000			
	Contingencies @ average of 14.6 % +/- *				$	305,000		(1)
06.3.-.-	**WILDLIFE FACILITIES AND SANCTUARIES**			**TOTAL:**	**$**	**2,400,000**		
11.-.-.-	**LEVEES AND FLOODWALLS**							
	Reach 1-Yolo Bypass East Levee							
	Sacramento Bypass to Ship Channel							
11.0.A.-	Mob., Demob. and Preparatory Work:	1	JOB	LS	30,000	4,500	15.0	
11.0.C.-	Permanent Access Roads and Parking:							
11.0.C.B	Site Work							
	Road Surfacing Aggregate	18,500	TON	16.00	296,000	44,400	15.0	
11.0.1.-	Levees:							
11.0.1.B	Site Work							
	Clearing and Grubbing	60	Acre	1,450.00	87,000	13,050	15.0	
	Remove & Waste Concrete Lining	33,000	SY	9.00	297,000	74,250	25.0	
	Remove & Waste 48" CMP	180	LF	9.00	1,620	405	25.0	
	Remove Stockpile Recompact Embank	2,500	CY	1.80	4,500	675	15.0	
	Excavation and Embankment							
	Stripping to waste 20 mi	57,600	CY	6.10	351,360	52,704	15.0	(3)
	Remove, Reuse Exist. Base as Fill	55,200	SY	0.40	22,080	3,312	15.0	
	Excavation for Inspection Trench	27,000	CY	3.70	99,900	24,975	25.0	(3,4)
	Embankment from Borrow 20 mi	622,000	CY	7.10	4,416,200	1,104,050	25.0	(3,4)
	Water, Compaction & Dust Control	33,000	MG	7.00	231,000	34,650	15.0	
	Remove Stockpile Existing Riprap	11,200	CY	10.00	112,000	28,000	25.0	
	Riprap	89,300	TON	19.00	1,696,700	254,505	15.0	
	Excavation, Struct-Retaining Wall	450	CY	2.50	1,125	169	15.0	
	Backfill, Struct-Retaining Wall	400	CY	7.60	3,040	456	15.0	
11.0.1.C	Concrete							
	Retaining Wall	75	CY	490.00	36,750	9,188	25.0	(2)
	Reinforcement Steel	11,000	LB	0.50	5,500	1,375	25.0	(2)
11.0.G.-	Drainage:							
11.0.G.C	Concrete							
	Flood Gate Structure	24	CY	530.00	12,720	3,180	25.0	(2)
11.0.G.E	Metals							
	Flood Gate	1	Each	19,000.00	19,000	4,750	25.0	(2)

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE $	AMOUNT $	CONTINGENCY $ *	CONTINGENCY % *	REASON
	Price Level as of 1 Oct-91					* (Figures Rounded)		
	FEDERAL							
11.-.-.-	**LEVEES AND FLOODWALLS**							
11.0.R.-	Associated General Items:							
11.0.R.B	Site Work							
	Seeding	54	Acre	1,200.00	64,800	9,720	15.0	
	Subtotal, Construction Costs:			$	7,788,295			
	Contingencies @ average of 22.0 % +/- *				$	1,711,705		(1)
	Reach 1-Yolo Bypass East Levee			**TOTAL:**	**$**	**9,500,000**		
	Reach 3-Sacramento Bypass South Levee							
	Sacramento Weir to Yolo Bypass							
11.0.A.-	Mob., Demob. and Preparatory Work:	1	JOB	LS	20,000	3,000	15.0	
11.0.C.-	Permanent Access Roads and Parking:							
11.0.C.B	Site Work							
	Road Surfacing Aggregate	4,100	TON	16.00	65,600	9,840	15.0	
11.0.1.-	Levees:							
11.0.1.B	Site Work							
	Clearing and Grubbing	11	Acre	1,200.00	13,200	1,980	15.0	
	Excavation and Embankment							
	Stripping to waste 17 Mi	8,000	CY	6.00	48,000	7,200	15.0	(3)
	Remove, Reuse Exist. Base as Fill	18,000	SY	0.40	7,200	1,080	15.0	
	Embankment from Borrow 17 Mi	62,000	CY	5.80	359,600	71,920	25.0	(3)
	Water, Compaction & Dust Control	3,200	MG	7.80	24,960	3,744	15.0	
	Excavation, Struct-Retaining Wall	330	CY	2.50	825	124	15.0	
	Backfill, Struct-Retaining Wall	300	CY	6.70	2,010	302	15.0	
11.0.1.C	Concrete							
	Retaining Wall	55	CY	490.00	26,950	6,738	25.0	(2)
	Reinforcement Steel	8,300	LB	0.50	4,150	1,038	25.0	(2)
11.0.R.-	Associated General Items:							
11.0.R.B	Site Work							
	Seeding	9	Acre	1,220.00	10,980	1,647	15.0	
	Subtotal, Construction Costs:			$	583,475			
	Contingencies @ average of 20.0 % +/- *				$	116,525		(1)
	Reach 3-Sacramento Bypass South Levee			**TOTAL:**	**$**	**700,000**		
	Subtotal, Construction Costs:			$	8,371,770			
	Contingencies @ average of 21.8 % +/- *				$	1,828,230		(1)
11.-.-.-	**LEVEES AND FLOODWALLS**			**TOTAL:**	**$**	**10,200,000**		

COST ESTIMATE

DETAILED ESTIMATE OF FIRST COST

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE $	COST $	CONTINGENCY $ *	CONTINGENCY % *	CONTINGENCY REASON
	Price Level as of 1 Oct-91					* (Figures Rounded)		
	FEDERAL							
30.-.-.-	**PLANNING, ENGINEERING & DESIGN**							
30.C.-.-	LOCAL COOPERATIVE AGREEMENTS							
30.C.A.-	Draft LCA	40	DAYS	560.00	22,400			
30.C.B.-	Final LCA & Financial Plan	20	DAYS	560.00	11,200			
30.C.1.-	LCA Negotiations	15	DAYS	560.00	8,400			
30.C.Z.-	Contingencies	1	JOB	LS		10,000		
30.D.-.-	ENVIRONMENTAL AND REGULATORY ACTIVITIES							
30.D.C.-	Supplemental EIS	155	DAYS	300.00	46,500			
30.D.2.-	401, 404, & ROD	45	DAYS	300.00	13,500			
30.D.Z.-	Contingencies	1	JOB	LS		10,000		
30.E.-.-	DESIGN RELATED ENGINEERING							
30.E.1.-	Subsurface Explorations	1	JOB	LS	60,000			
30.E.2.-	Sampling, Testing, & Analysis	1	JOB	LS	30,000			
30.E.Z.-	Contingencies	1	JOB	LS		30,000		
30.F.-.-	FEATURE DESIGN MEMORANDUM (FDM)							
30.F.A.-	Draft FDM	800	DAYS	310.00	248,000			
30.F.B.-	Final FDM	270	DAYS	310.00	83,700			
30.F.F.-	Value Engineering (VE) Studies	90	DAYS	360.00	32,400			
30.F.Z.-	Contingencies	1	JOB	LS		100,000		
30.H.-.-	PLANS AND SPECIFICATIONS							
30.H.A.-	Preliminary Design	265	DAYS	300.00	79,500			
30.H.B.-	Final Design	90	DAYS	300.00	27,000			
30.H.C.-	Design Revisions	90	DAYS	300.00	27,000			
30.H.E.-	BCO Review	45	DAYS	300.00	13,500			
30.H.Z.-	Contingencies	1	JOB	LS		45,000		
30.J.-.-	ENGINEERING DURING CONSTRUCTION							
30.J.H.-	Value Engineering Change Proposals	40	DAYS	360.00	14,400			
30.J.1.-	Review of E&D Effort by Construction Contractor	40	DAYS	310.00	12,400			
30.J.2.-	Periodic Inspections	20	DAYS	310.00	6,200			
30.J.9.-	All Other Engineering During Constr	120	DAYS	310.00	37,200			
30.J.Z.-	Contingencies	1	JOB	LS		30,000		
30.M.-.-	COST ENGINEERING							
30.M.1.-	Studies	65	DAYS	310.00	20,150			
30.M.2.-	Design Memorandums	90	DAYS	310.00	27,900			
30.M.3.-	Bid Estimate	25	DAYS	310.00	7,750			
30.M.Z.-	Contingencies	1	JOB	LS		10,000		
30.P.-.-	PROJECT MANAGEMENT	530	DAYS	400.00	212,000			
30.P.Z.-	Contingencies	1	JOB	LS		50,000		
30.Z.-.-	MISCELLANEOUS ACTIVITIES							
30.Z.1.-	FWS Support	1	JOB	LS	50,000			
30.Z.2.-	Surveys (Topographical)	1	JOB	LS	150,000			
30.Z.3.-	Surveys (Cultural)	1	JOB	LS	50,000			
30.Z.Z.-	Contingencies:	1	JOB	LS		80,000		
	Subtotal, Construction Costs:			$	1,291,100			
	Contingencies @ average of 28.6 % +/- *				$	368,900		(1)
30.-.-.-	**PLANNING, ENGINEERING & DESIGN**		**TOTAL:**		**$**	**1,660,000**		

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE $	COST $	CONTINGENCY $ *	% *	REASON
	Price Level as of 1 Oct-91					* (Figures Rounded)		
	FEDERAL							
31.-.-.-	**CONSTRUCTION MANAGEMENT (S & I)**							
31.B.-.-	CONTRACT ADMINISTRATION							
31.B.1.-	Pre-award Activities	90	DAYS	310.00	27,900			
31.B.2.-	Award Activities	20	DAYS	310.00	6,200			
31.B.3.-	Review-Approval of Contract Payment	30	DAYS	310.00	9,300			
31.B.4.-	Contract Modifications	45	DAYS	310.00	13,950			
31.B.5.-	Progress and Completion Reports	20	DAYS	310.00	6,200			
31.B.Z.-	Contingencies	1	JOB	LS		30,000		
31.C.-.-	BENCH MARKS AND BASELINES	1	JOB	LS	50,000			
31.C.Z.-	Contingencies	1	JOB	LS		20,000		
31.D.-.-	REVIEW OF SHOP DRAWINGS	145	DAYS	310.00	44,950			
31.D.Z.-	Contingencies	1	JOB	LS		15,000		
31.E.-.-	INSPECTION AND QUALITY ASSURANCE							
31.E.1.-	Schedule Compliance	20	DAYS	310.00	6,200			
31.E.2.-	Compliance Sampling & Testing	1	JOB	LS	40,000			
31.E.3.-	Quantity Surveys	1	JOB	LS	20,000			
31.E.9.-	Q.A. Personnel	1,430	DAYS	310.00	443,300			
31.E.Z.-	Contingencies	1	JOB	LS		130,000		
31.F.-.-	PROJECT OFFICE OPERATION	1	JOB	LS	100,000			
31.F.Z.-	Contingencies	1	JOB	LS		25,000		
31.G.-.-	DAMAGES ASSESSED CONTRACTORS	1	JOB	LS	10,000			
31.G.Z.-	Contingencies	1	JOB	LS		10,000		
31.H.-.-	CONTRACTOR CLAIMS AND LITIGATIONS	1	JOB	LS	10,000			
31.G.Z.-	Contingencies	1	JOB	LS		10,000		
31.J.-.-	GOVERNMENT CLAIMS AND LITIGATIONS	1	JOB	LS	10,000			
31.G.Z.-	Contingencies	1	JOB	LS		10,000		
31.P.-.-	PROJECT MANAGEMENT	200	DAYS	310.00	62,000			
31.G.Z.-	Contingencies	1	JOB	LS		20,000		
	Subtotal, Construction Costs:			$	860,000			
	Contingencies @ average of 31.4 % +/- *				$	270,000		(1)
31.-.-.-	**CONSTRUCTION MANAGEMENT (S & I)**		TOTAL:		$	**1,130,000**		

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE $	COST $	CONTINGENCY $ *	CONTINGENCY % *	REASON
	Price Level as of 1 Oct-91					* (Figures Rounded)		
	NON-FEDERAL							
01.-.-.-	LANDS AND DAMAGES							
01.A.-.-	PRE-AUTHORIZATION PLANNING							
01.A.1.-	Develop Cost Estimate	2	MD	550.00	1,100			
01.A.2.-	Develop Acquisiton Schedule	2	MD	550.00	1,100			
01.A.9.-	Contingencies	1	JOB	LS		300		
01.B.-.-	POST-AUTHORIZATION PLANNING							
01.B.1.-	Develop Cost Estimate	2	MD	550.00	1,100			
01.B.2.-	Develop Acquisiton Schedule	2	MD	550.00	1,100			
01.B.9.-	Contingencies	1	JOB	LS		300		
01.D.-.-	ACQUISITIONS							
01.D.1.-	Attorney's Opinion							
01.D.1.E	Review of Documents	5	MD	440.00	2,200			
01.D.1.Z	All Other	5	MD	880.00	4,400			
01.D.2.-	Mapping, Survey and Tract Ownership							
01.D.2.D	Prepare Documents	72	MD	460.00	33,120			
01.D.2.E	Review of Documents	48	MD	460.00	22,080			
01.D.2.F	Review for Compliance	24	MD	460.00	11,040			
01.D.2.Z	All Other	37	MD	415.00	15,355			
01.D.3.-	Title Evidence							
01.D.3.D	Prepare Documents	24	MD	460.00	11,040			
01.D.3.Z	All Other	12	MD	460.00	5,520			
01.D.4.-	Negotiations and Closing							
01.D.4.D	Prepare Documents	120	MD	460.00	55,200			
01.D.4.E	Review of Documents	48	MD	460.00	22,080			
01.D.4.F	Review for Compliance	24	MD	460.00	11,040			
01.D.4.Z	All Other	24	MD	550.00	13,200			
01.D.5.-	Condemnation (Pre-DT Filing)							
01.D.5.D	Prepare Documents	12	MD	450.00	5,400			
01.D.5.E	Review of Documents	5	MD	440.00	2,200			
01.D.5.F	Review for Compliance	2	MD	550.00	1,100			
01.D.5.Z	All Other	2	MD	550.00	1,100			
01.D.9.-	Contingencies	1	JOB	LS		32,300		
01.E.-.-	CONDEMNATION (POST-DT FILING)							
01.E.0.D	Prepare Documents	10	MD	440.00	4,400			
01.E.0.E	Review of Documents	2	MD	550.00	1,100			
01.E.0.F	Review for Compliance	2	MD	550.00	1,100			
01.E.0.Z	All Other	1	JOB	LS	30,000			
01.E.9.-	Contingencies	1	JOB	LS		5,500		

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE $	AMOUNT $	CONTINGENCY $ *	CONTINGENCY % *	REASON
	Price Level as of 1 Oct-91					* (Figures Rounded)		
	NON-FEDERAL							
01.-.-.-	**LANDS AND DAMAGES**							
01.F.-.-	APPRAISALS							
01.F.1.-	Staff Appraisals							
01.F.1.H	Prepare Documents	120	MD	460.00	55,200			
01.F.1.J	Review of Documents	5	MD	440.00	2,200			
01.F.1.F	Review for Compliance	43	MD	460.00	19,780			
01.F.1.Z	All Other	24	MD	460.00	11,040			
01.F.2.-	Contract Appraisals							
01.F.2.H	Prepare Documents	1	JOB	LS	5,000			
01.F.2.J	Review of Documents	2	MD	550.00	1,100			
01.F.9.-	Contingencies	1	JOB	LS		17,100		
01.K.-.-	TEMPORARY PERMITS							
01.K.0.D	Prepare Documents	10	MD	440.00	4,400			
01.K.0.E	Review of Documents	5	MD	440.00	2,200			
01.K.0.Z	All Other	1	MD	700.00	700			
01.K.9.-	Contingencies	1	JOB	LS		1,200		
01.M.-.-	REAL ESTATE RECEIPTS/PAYMENTS							
01.M.3.-	Land Payments	1	JOB	LS	955,200			
01.M.5.-	Damage Payments	1	JOB	LS	31,700			
01.M.9.-	Contingencies	1	JOB	LS		276,900		
	Subtotal, Construction Costs:			$	1,345,595			
	Contingencies @ average of 26.3 % +/- *				$	354,405		(a)
01.-.-.-	**LANDS AND DAMAGES**			**TOTAL:**	**$**	**1,700,000**		
02.-.-.-	**RELOCATIONS**							
02.3.-.-	**CEMETERIES, UTILITIES, AND STRUCTURES** **Construction Activities**							
	Reach 1-Yolo Bypass East Levee							
02.3.2.-	Utilities							
02.3.2.R	Electrical							
	Telephone pole	1	Each	1,600.00	1,600	100	6.3	
02.3.3.-	Structures							
02.3.3.B	Site Work							
	Fencing	400	LF	15.00	6,000	300	5.0	
	Subtotal, Construction Costs:			$	7,600			
	Contingencies @ average of 5.3 % +/- *				$	400		(1)
	Reach 1-Yolo Bypass East Levee			**TOTAL:**	**$**	**8,000**		

COST ESTIMATE

DETAILED ESTIMATE OF FIRST COST   TABLE 2

ACCOUNT NUMBER	ITEM	QUANTITY	UNIT	UNIT PRICE $	AMOUNT $	CONTINGENCY $ *	CONTINGENCY % *	REASON
	Price Level as of 1 Oct-91					*** (Figures Rounded)**		
	NON-FEDERAL							
02.3.-.-	**CEMETERIES, UTILITIES, AND STRUCTURES**							
	Construction Activities							
	Reach 3-Sacramento Bypass South Levee							
02.3.2.-	Utilities							
02.3.2.R	Electrical							
	Remove and Relocate cable poles	4	Each	1,600.00	6,400	300	4.7	
02.3.Z.-	Contingencies:	1	JOB	LS		300		
	Subtotal, Construction Costs:			$	6,400			
	Contingencies @ average of 9.4 % +/- *				$	600		(1)
	Reach 3-Sacramento Bypass South Levee			**TOTAL:**	**$**	**7,000**		
02.3.-.-	**CEMETERIES, UTILITIES, AND STRUCTURES**			**TOTAL:**	**$**	**15,000**		
30.-.-.-	**PLANNING, ENGINEERING & DESIGN**							
30.A.-.-	PLANNING, ENGINEERING & DESIGN	1	JOB	LS	4,000	1,000	25.0	
	Subtotal, Construction Costs:			$	4,000			
	Contingencies @ average of 25.0 % +/- *				$	1,000		(1)
30.-.-.-	**PLANNING, ENGINEERING & DESIGN**			**TOTAL:**	**$**	**5,000**		
31.-.-.-	**CONSTRUCTION MANAGEMENT (S & I)**							
31.A.-.-	CONSTRUCTION MANAGEMENT (S&I)	1	JOB	LS	1,500	500	33.3	
	Subtotal, Construction Costs:			$	1,500			
	Contingencies @ average of 33.3 % +/- *				$	500		(1)
31.-.-.-	**CONSTRUCTION MANAGEMENT (S & I)**			**TOTAL:**	**$**	**2,000**		

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE $	COST $	CONTINGENCY $ *	CONTINGENCY % *	CONTINGENCY REASON
	Price Level as of 1 Oct-91					* (Figures Rounded)		
	FEDERAL							
18.-.-.-	**CULTURAL RESOURCE PRESERVATION**							
18.0.1.-	Identification, Data Analysis and Reports:	1	JOB	LS	9,000			
18.0.2.-	Recover and Remove Artifacts:	1	JOB	LS	4,000			
18.0.3.-	Preservation on Site:							
18.0.3.B	Site Work							
	Special Excavation	1	JOB	LS	85,000			
18.0.Z.-	Contingencies:					32,750		
	Subtotal, Construction Costs:			$	98,000			
	Contingencies @ average of 33.7 % +/- *				$	33,000		(1)
18.-.-.-	**CULTURAL RESOURCE PRESERVATION**		TOTAL:		$	**131,000**		

COST ESTIMATE
SUMMARY OF ANNUAL COST **TABLE 3**

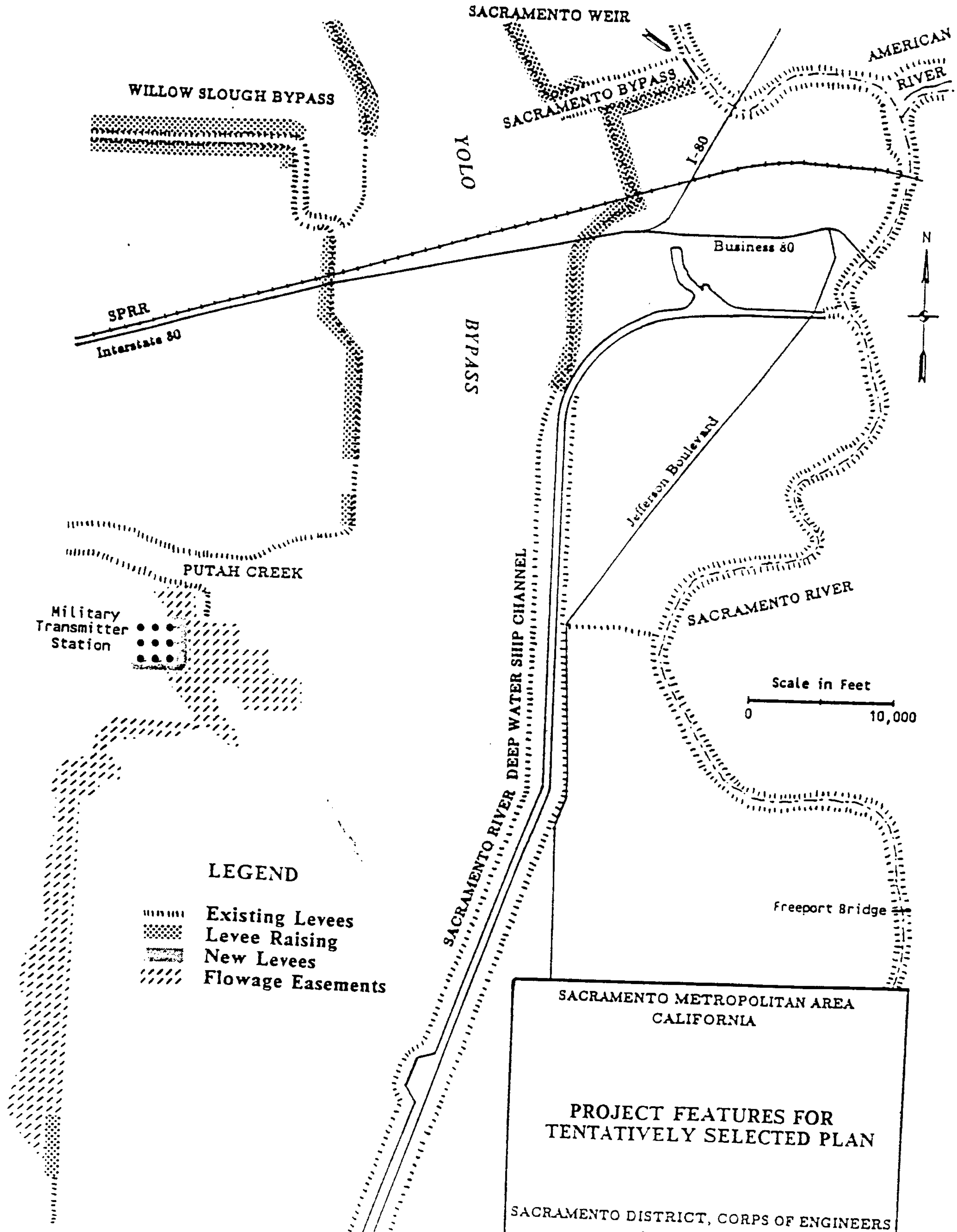
ITEM	COST $
Price Level as of 1 Oct-91	
	8.750%
A. INVESTMENT COST	
1. FEDERAL	
TOTAL	14,270,000
2. NON-FEDERAL	
TOTAL	4,713,000
TOTAL PROJECT INVESTMENT	**18,983,000**
B. ANNUAL COSTS	
1. FEDERAL	
TOTAL	1,270,000
2. NON-FEDERAL	
TOTAL	410,000
TOTAL PROJECT ANNUAL COST	**1,680,000**

COST ESTIMATE

DETAILED ESTIMATE OF ANNUAL COST **TABLE 4**

ITEM		COST $
Price Level as of 1 Oct-91		
		8.750%
A. INVESTMENT COST		
1. FEDERAL		
a. First Cost		13,100,000
b. Interest During Construction		1,170,000
TOTAL		**14,270,000**
2. NON-FEDERAL		
a. First Cost		4,323,000
b. Interest During Construction		390,000
TOTAL		**4,713,000**
TOTAL PROJECT INVESTMENT		**18,983,000**
B. ANNUAL COSTS		
1. FEDERAL		
a. Interest Rate	8.750%	1,250,000
TOTAL		**1,250,000**
2. NON-FEDERAL		
a. Interest Rate	8.750%	410,000
d. Maintenance And Operation:		20,000
11 Levees	20,000	
TOTAL		**430,000**
TOTAL PROJECT ANNUAL COST		**1,680,000**

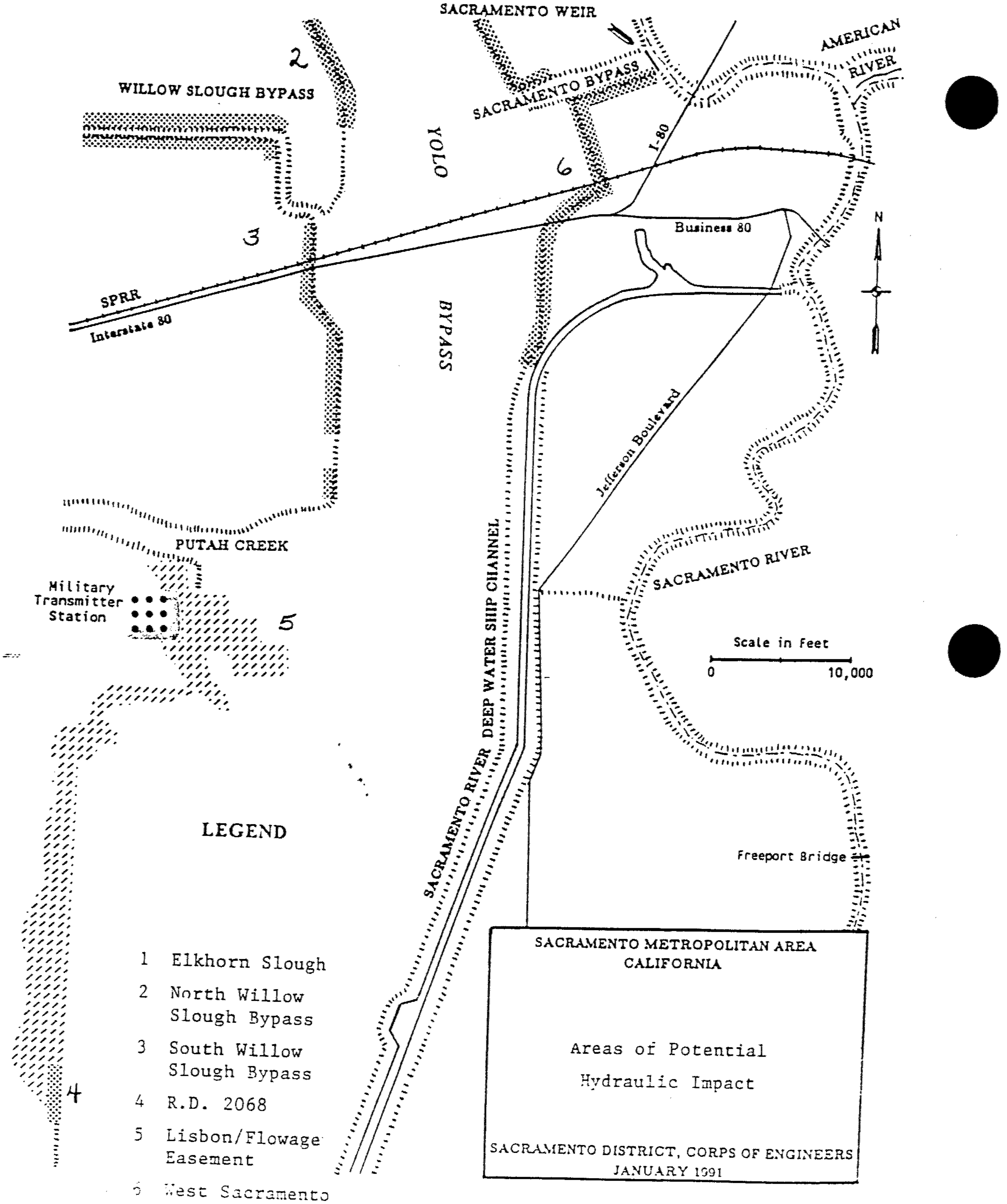
PLATES



SACRAMENTO METROPOLITAN AREA
CALIFORNIA

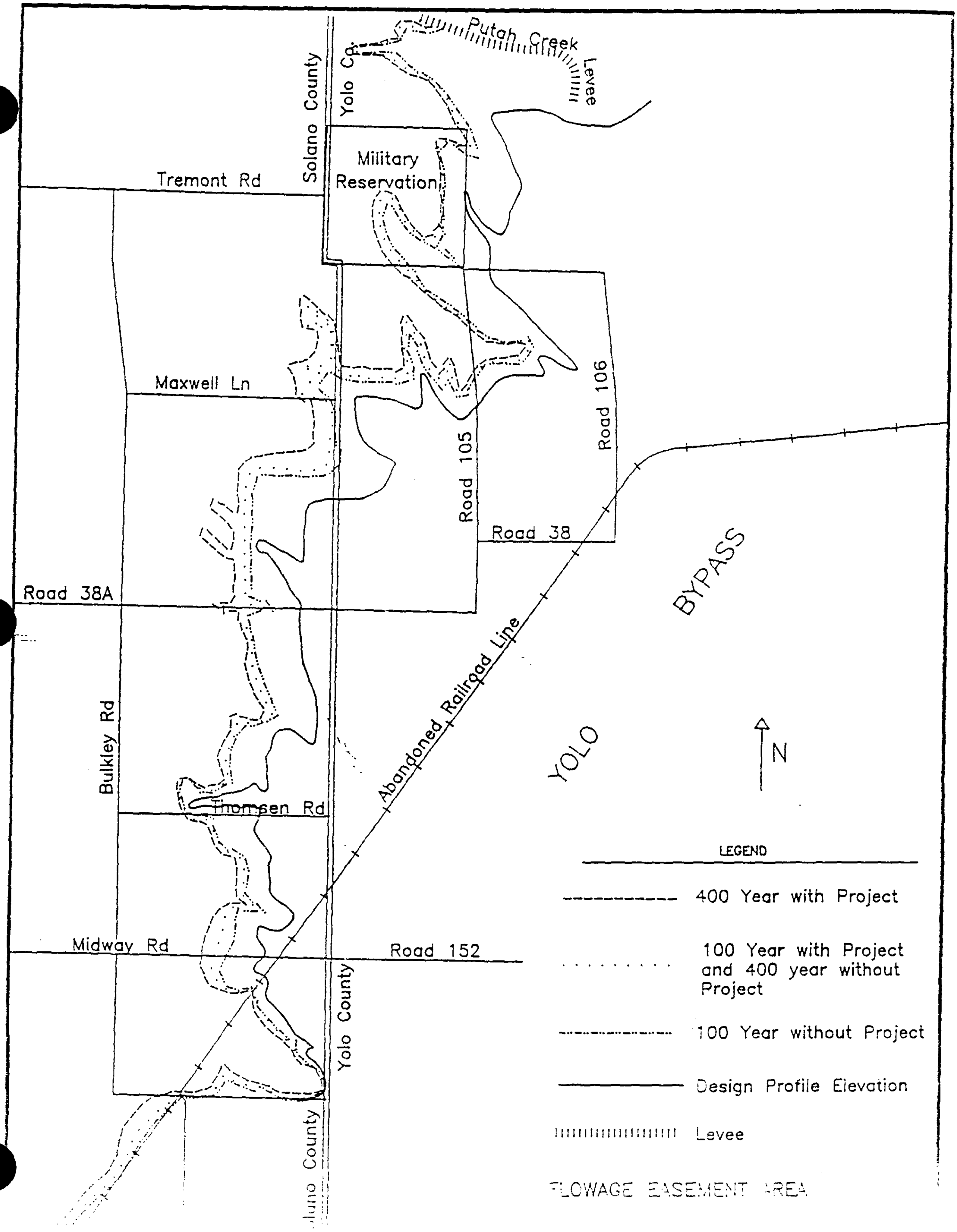
PROJECT FEATURES FOR
TENTATIVELY SELECTED PLAN

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1991



SACRAMENTO WEIR
AMERICAN RIVER
SACRAMENTO BYPASS
WILLOW SLOUGH BYPASS
YOLO
BYPASS
I-80
SPRR
Interstate 80
Business 80
N
Jefferson Boulevard
DEEP WATER SHIP CHANNEL
SACRAMENTO RIVER
PUTAH CREEK
Military Transmitter Station
SACRAMENTO RIVER
Scale in Feet
0
10,000
Freeport Bridge
1
2
3
4
5
6
LEGEND
1 Elkhorn Slough
2 North Willow Slough Bypass
3 South Willow Slough Bypass
4 R.D. 2068
5 Lisbon/Flowage Easement
6 West Sacramento
SACRAMENTO METROPOLITAN AREA
CALIFORNIA
Areas of Potential
Hydraulic Impact
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JANUARY 1991

PLATE



Putah Creek Levee
Yolo Co.
Solano County
Military Reservation
Tremont Rd
Maxwell Ln
Road 106
Road 105
Road 38
Road 38A
BYPASS
YOLO
Abandoned Railroad Line
N
Bulkley Rd
Thomsen Rd
Midway Rd
Road 152
Yolo County
Solano County
LEGEND
400 Year with Project
100 Year with Project and 400 year without Project
100 Year without Project
Design Profile Elevation
Levee
FLOWAGE EASEMENT AREA

SACRAMENTO METROPOLITAN AREA, CALIFORNIA

FEASIBILITY REPORT

APPENDIX E

LEVEE ENLARGEMENT INVESTIGATION FOR YOLO BYPASS LEVEES

LEVEE ENLARGEMENT INVESTIGATION FOR YOLO BYPASS LEVEES

SACRAMENTO METROPOLITAN AREA

Prepared By

Soil Design Section, Geotechnical Branch

U. S. Army Engineer District, Sacramento

Corps of Engineers

TABLE OF CONTENTS

TABLES

TABLE OF CONTENTS (Continued)

PLATES

Plate No.

ENCLOSURES

Enclosure No.

1. PURPOSE

This report describes the results of stability analyses for levees along the east side of the Yolo Bypass between the Sacramento Bypass and the Sacramento Deep Water Ship Channel (see Plate 1). The stability analyses were performed for a levee height increase of 7 feet for RD-537 and 6 feet for RD-900. The results of this study provide feasibility level information for levee enlargement.

2. SCOPE

The effort required for this study was outlined in Work Order Request 198-90-01B dated 23 January 1990. The study consisted of the following:

a. Field measurement of typical levee cross sections.

b. Stability analyses of each typical levee cross section considering embankment enlargement.

c. Provide preliminary recommendations for levee enlargement in the following reaches (see Plate 1):

1. Yolo Bypass East Levee between the Sacramento Bypass South Levee and the north side berm of the Southern Pacific Railroad (RD 537,"California Highway Patrol Academy Site").

2. Yolo Bypass East Levee from the south side berm of the Southern Pacific Railroad to the north side berm of the Yolo Causeway (RD 900, "Auction Yard Site").

3. Yolo Bypass East Bank Levee from the south side of the Yolo Causeway to the Sacramento Deep Water Ship Channel (RD 900, "Industrial Park Site").

3. GENERAL

The selection of soil shear strength values used in the stability analyses were based on previous laboratory shear strength test results performed by the South Pacific Division Laboratory for inclusion in Wahler Associates', *Levee Investigation Report, (August 1987)* and *Stability Analyses of RD-900 Yolo Bypass Levee (November, 1989)*. The locations of the explorations performed by Wahler Associates are shown on Plate 1. A levee and foundation soil profile of the RD 537 and RD 900 Auction Yard Site levee reaches are shown on Plates 2 and 2.1. A summary of the laboratory shear strength test results performed on undisturbed samples are shown on Plates 3 and 4.

For reference, the field logs prepared by Wahler Associates are included as Enclosure 1 through 11. It is anticipated that borrow material will be obtained from either the Sacramento Bypass or the Corps of Engineers Dredge Disposal Site located just south of the confluence of the the Barge Canal and the Sacramento River. Explorations conducted in the Sacramento Bypass in 1990 for the Sacramento Area Urban Levee Reconstruction Project indicate these soils are primarily silty sand (SM) and sandy clay (CL). Prior to preparation of the Basis of Design, additional explorations and laboratory testing of the existing levee, foundation and borrow materials will be performed. The results of the additional tests will serve to verify the material properties selected for this study. Shear strength values and unit weights used in the analyses are discussed below:

a. Levee Embankment. The existing levee materials located within the upper 15 to 20 feet, generally consist of firm to stiff, moderate to highly plastic silty clay (CL-CH) with traces of fine sand. Shear strength values used for the levee soils were based on four unconfined-compression (UC) tests, four unconsolidated-undrained (Q) triaxial compression tests and three consolidated-undrained (R) triaxial compression tests (see Plate 3). Saturated and moist unit weights used for the levee and foundation materials were based on density values of undisturbed samples. A soil profile showing levee and foundation soil types prepared by Wahler Associates for the Sacramento Urban Area Basis of Design is shown on Plate 2.

For long term stability, a cohesion intercept of c = 600 pounds per square foot (psf), with an angle of internal friction, $\phi = 11°$ was selected. A saturated unit weight $\gamma = 110$ pounds per cubic foot (pcf) and a moist unit weight $\gamma = 100$ pcf was utilized in the analyses. For the end-of-construction (EOC) condition, a cohesion intercept value of c = 1000 psf, and $\phi = 0°$ was used.

b. Foundation. The foundation soils generally consist of firm, moderate to highly plastic, silty clay (CH) extending to depth of 20 feet below the levee-foundation interface. Some layers of organic silt/clay, with an organic content as high as 6 percent were encountered in some borings. It was suggested by representatives of RD 900 that a thin, weak layer exists at the levee/foundation contact. Explorations to date do not indicate this to be the case. Therefore, this analyses did not consider a weak layer in the foundation. No groundwater was encountered during recent drilling (November,1989), although, it was noted that moisture contents increased noticeably with depth within foundation materials. Shear strength values used for the foundation soils were based on two unconfined-compression tests, seven unconsolidated-undrained triaxial compression tests and three consolidated-undrained triaxial compression test (see Plate 4). For the purpose of approximating actual field conditions, a small linear increase in strength of 10 psf per foot of depth was assumed.

For long term stability, a cohesion intercept value of c = 400 psf, and a friction angle of $\phi = 12°$ was selected for the entire foundation depth. For the EOC analysis, a cohesion value of c = 800 psf increasing by 10 psf per foot of depth was used. A saturated and moist unit weight of $\gamma = 120$ pcf was used for foundation soils.

c. New Levee Fill. Shear strength values selected for new levee fill materials were chosen based on similar materials and engineering judgement. Although no specific strength tests

were performed on proposed borrow materials, it was assumed that the new levee fill would possess overall, slightly higher shear strength parameters than the existing levee materials. The unconsolidated-undrained shear strength used in the analyses had a cohesion value of c = 1500 psf, and a friction angle of $\phi = 10°$. For long term stability, the assumed strength was c = 600 psf, with a friction angle of $\phi = 15°$.

4. RECLAMATION DISTRICT 537 (CHP Academy Site)

a. Description. Levee cross sections included one field surveyed by Wahler Associates, and three field surveyed by the Corps of Engineers. From these four sections, a single "composite" typical cross section was developed. The final composite cross section is indicated with a dashed line (Plates 5 and 6) and is shown on all stability analysis plates for both conditions analyzed. This approach was used for the other two reaches.

The locally constructed levee which measures approximately 7,000 linear feet (LF), was improved by the Corps of Engineers in 1941. The improvements included providing a 20-foot crest width, and side slopes of 1 vertical (V) on 2 horizontal (H) for both the landside and the waterside slopes. The original below grade levee with a 1(V) on 4(H) waterside and 1(V) on 3(H) landside slope was left in place.

b. Stability Analysis Results. A slope stability analyses was performed to determine the critical failure arc for the composite cross section selected. The UTEXAS2 slope stability computer program, developed by Stephen Wright of the University of Texas at Austin, was used for analyzing all of the cross sections. The analytical method employed in the computer program was the Simplified Bishop (1955) procedure.

The two conditions analyzed were end-of-construction and long term stability. Also, included in the stability calculations, was the assumption of a 12-foot deep vertical "tension" crack extending into the embankment and water was considered to the full height in the crack. The location of the tension crack was independently chosen by the computer program, and was based on the location of the critical failure arc.

Some levee saturation is anticipated during the relatively short flood duration. However, due to the generally low permeability of the clay soils that comprise the existing levee, only a portion of the embankment was assumed saturated in the analysis. The estimated phreatic surface through the embankment is shown on Plates 5, 7, 9, and 11. Sudden drawdown levee slope failures have been esentially nonexistent in the flood control system. This is primarily due to the relatively short flood durations and low permeable soil types in some locations. However, in order to conservatively estimate the potential for sudden drawdown slope failure, a stability analysis was performed. The results are discussed in paragraph 5b.

An increase in height of 7 feet was used for the new embankment. A 6-foot design freeboard was used for all three reaches. Several different landside and waterside slopes were evaluated. The required minimum factor of safety (FS) of 1.3 (end-of-construction) was achieved using 1(V) on 3(H) landside and waterside slopes. The minimum FS for the end-of-construction condition occurred along the landside slope and was 1.48. The minimum factor of safety for long term stability was 1.47 (1.4 required). The critical failure arcs are shown on Plates 5 and 6. Table 1.1 includes these results as well as the factors of safety for all of the reaches studied.

TABLE 1.1 - LEVEE ENLARGEMENT STABILITY

SITE	FACTORS OF SAFETY			
	EOC		LONG TERM	
	REQUIRED	RESULTS	REQUIRED	RESULTS
RD 537	1.3	1.5	1.4	1.5
RD 900 (BERM AREA)	1.3	1.6	1.4	1.5
RD 900 (DITCH AREA)	1.3	1.7	1.4	1.8
RD 900 (INDUSTRIAL PARK SITE)	1.3	1.9	1.4	2.1

c. Design Considerations. An irrigation drainage ditch, located at the landside toe, parallels a majority of the reach and posses construction difficulties and serious environmental impacts associated with it's removal. Therefore, levee work on the landside is not considered a practical alternative. Waterside or Yolo Bypass side construction is tentatively selected because this method offers better cost effective construction procedures, and would pose less impacts to the surrounding environment. However, some removal of trees and vegetation along the waterside toe would be required. An inspection trench beneath the expanded levee section is also recommended. The inspection trench would serve to identify undesirable foundation soils such as organics or pervious sand lenses.

5. RECLAMATION DISTRICT 900 (Auction Yard Site)

a. Description. Levee cross sections used for this reach included two developed by Wahler Associates, and four sections field surveyed by the Corps. Based on the six sections analyzed, it was determined that two composite cross sections would represent this reach, which measures close to 5,000 LF. The two final cross sections are shown as dashed lines on Plates 7 through 10.

Two general types of levee geometry exist; one cross section includes a landside drainage ditch approximately 2,300 feet long and about 40 feet wide, while the other section includes a 1983 PL 99 landside stability berm about 600 feet long. Along the remaining sections of levee, located near the eastern and western ends of the reach, fill and concrete rubble has been stockpiled in the area adjacent to the waterside and landside levee toes.

In 1932, this entire length of levee was enlarged approximately 5 feet, utilizing a 20-foot crest width, 1(V) on 2(H) landside and 1(V) on 3(H) waterside slopes. This enlarged levee performed adequately until landside stability problems developed during the 1983 flood. Permanent repairs were subsequently made by the Corps. This work included the 600-foot gravel stability berm located near the northeast end of the reach, and four reconstructed levee sections totaling approximately 1,300 feet.

b. Stability Analysis Results. A slope stability analyses was performed to determine the critical failure surface for the two composite cross sections selected. End-of-construction and long term stability conditions were studied. Included in the stability calculations was the assumption of a 10-foot deep, water filled vertical tension crack. Selected shear strength values used for the gravel berm materials reflect higher strengths and better drainage capabilities associated with these materials. A cohesion value of $c = 0$ psf, and a friction angle of $\phi = 36°$ was selected. The analyses assumed that the existing drainage ditch would be backfilled before enlarging the levee. The minimum required factors of safety were achieved with 1(V) on 3(H) landside and waterside slopes.

For the "berm area" typical cross section, the minimum FS for EOC condition was 1.63 (1.3 required). The minimum FS for long term stability was 1.54 (1.4 required). The critical failure arcs for both conditions are shown on Plates 7 and 8. For the "ditch area", the minimum factor of safety computed for EOC condition was 1.73. The minimum FS calculated for long term stability was 1.76. The critical failure surfaces are shown on Plates 9 and 10.

Although slope instability due to sudden drawdown is not considered critical, this condition was analyzed. A conservative phreatic surface exiting at the levee landside toe was used in the analysis. The resulting minimum factor of safety obtained was 1.56. The minimum required factor of safety is 1.0. The critical failure arc is shown on Plate 9.

c. Design Considerations. Along a 200-foot portion of the waterside slope, there remains an old, broken concrete wall and armoring slab surface. This structure has deteriorated substantially, and should be demolished and removed, before the new embankment is constructed. It is recommended that the 2,300-foot long drainage ditch be backfilled prior to enlarging the levee. The existing gravel stability berm would require extension, starting from the existing berm and ending at the new landside levee toe. The excavation of an inspection trench beneath the expanded levee section is also recommended.

6. RECLAMATION DISTRICT 900 (Industrial Park Site)

a. Description. Levee cross sections used for this reach, included one developed by Wahler Associates, and five sections field surveyed by the Corps of Engineers. Based on the

available cross section data, a single composite cross section was developed to represent a typical levee section. The final cross section is shown as a dashed line on Plates 11 and 12. This levee reach was locally constructed, and measures approximately 9,500 feet in length. The Corps made improvements to this levee at one location in 1934 and at another location in 1940. In 1934, the levee height was increased three feet and the crest widened to 20 feet and approximately 7,000 LF were reshaped providing 1(V) on 3(H) waterside and landside slopes. In 1940, a substantial levee repair was performed on approximately 1,600 LF of levee. The repairs involved excavating and recompacting a large portion of the levee section to include the construction of an 8-foot wide by 6-foot deep trapezoidal inspection trench. The levee repairs also involved increasing the levee height an additional 5 feet, and constructing 1(V) on 3(H) waterside and landside slopes and providing a 20-foot crest width. Approximately 900 LF of levee has been left unchanged since it's original construction.

b. Stability Analysis Results. Stability analyses were performed to determine the critical failure surface for the cross section selected. The stability calculations included the assumption of a 10-foot deep, water filled vertical tension crack.

An increased height of six feet was used for the analyses. This included a 6-foot design freeboard. The required minimum FS of 1.3 or greater was achieved using 1(V) on 3(H) waterside and 1(V) on 2(H) landside slopes, along with a 20-foot crest width. The minimum FS for end-of-construction condition was 1.86 (1.3 required). The minimum FS for long term stability was 2.08 (1.4 required). The critical failure arcs for each condition analyzed are shown on Plates 11 and 12.

c. Design Considerations. It is recommended that an inspection trench be excavated beneath the expanded levee section, because of historical slope stability problems. In addition to the inspection trench, all drainage ditches within 50 feet of the landside toe should be backfilled.

7. CONCLUSIONS

Stability analyses were performed on a total of four typical cross sections within the study area. The analyses assessed the stability of the levees, assuming a 7-foot increase in height for RD-537 levees and a 6-foot increase in height for RD-900 levees. Based on the results of the stability analyses, enlargement of the levee can be constructed, however, some remedial foundation work will be required. The results of the analyses also indicate that new waterside and landside slopes should be flattened to 1(V) on 3(H). Based on limited subsurface soil explorations and laboratory test information, the enlarged levees will function as designed. The following provides a general discussion of foundation strength.

a. RD-537 (CHP Academy Site). With the addition of 7 feet of fill material, there does not appear to be stability problems in this section of levee (FS = 1.47). However, the computed factor of safety is marginal and may be lower than the stability analysis indicates. Based on the subsurface conditions indicated in the borings, along with a history of crown settlement, lateral

spreading or gradual outward slope movement could develop under the new loading. Therefore, it is appropriate to consider remedial stabilizing measures along this reach of levee.

b. RD-900 (Auction Yard Site). Along this section of levee, a majority of the unstable portions were repaired in 1983-84 by constructing the landside stability berm. Assuming a 6-foot increase in height this section of levee appears to be relatively stable (FS = 1.54). However, it is noted that the levee has a history of failures, the quality of construction is questionable and the foundation is weak and was not adequately prepared. Thus, increasing the height of the levee may reduce the slope stability factor of safety below acceptable standards. Therefore, a much more detailed subsurface investigation to evaluate and locate areas of foundation instability should be conducted.

c. RD-900 (Industrial Park Site). With an increase in height of 6 feet, the stability analysis indicated adequate stability exists (FS = 1.86). Based upon the borings, the foundation soils have a slightly higher strength than the other two reaches studied. Thus, levee enlargement is considered feasible.

8. RECOMMENDATIONS

Prior to final design, assumed shear strength values used in the stability analysis should be verified. This should be accomplished by completing a detailed exploration and laboratory testing program. Such a program would require a series of appropriate triaxial compression tests on remolded borrow samples and undisturbed levee and foundation samples. The exploration program should include closely spaced borings drilled at the crest and toe of the levee. Following the laboratory testing program, a reanalyses should be performed to confirm the stability results of this study. For estimating and planning purposes the sections analyzed in this report are recommended.

9. <u>REFERENCES</u>

a. Wahler Associates, 1987. *Levee Investigation for Reclamation District's 537 and 900 and Maintenance Areas 4 and 9, Sacramento River, Sacramento Bypass and Yolo Bypass, Yolo and Sacramento Counties, California.* Prepared for: DEPARTMENT OF THE ARMY, Sacramento District, Corps of Engineers.

b. Wahler Associates, 1989. *Stability Analyses of RD-900 Yolo Bypass Levee Between the SPRR and Interstate 80, Yolo County, California.* Prepared for: DEPARTMENT OF THE ARMY, Sacramento District, Corps of Engineers.

c. DEPARTMENT OF THE ARMY, U S Army Corps of Engineers, 1978. *Engineer Manual 1110-2-1913 - Design and Construction of Levees,* Washington, D.C.

d. Wright, Stephen G. and Edris, Earl V., 1987. *User's Guide: UTEXAS2 Slope-Stability Package.* Prepared for: DEPARTMENT OF THE ARMY, U S Army Corps of Engineers, Washington, D.C.

ENCLOSURES

ENCLOSURES

UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D-2487)

PRIMARY DIVISIONS			GROUP SYMBOL	SECONDARY DIVISIONS
COARSE GRAINED SOILS MORE THAN HALF OF MATERIALS IS LARGER THAN #200 SIEVE SIZE	GRAVELS MORE THAN HALF OF COARSE FRACTION IS LARGER THAN #4 SIEVE	CLEAN GRAVELS (LESS THAN 5% FINES)	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
			GP	POORLY GRADED GRAVELS OR GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
		GRAVEL WITH FINES	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURE, NON PLASTIC FINES.
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES. PLASTIC FINES.
	SANDS MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN #4 SIEVE	CLEAN SANDS (LESS THAN 5% FINES)	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES.
			SP	POORLY GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES.
		SANDS WITH FINES	SM	SILTY SANDS, SAND-SILT MIXTURES, NON-PLASTIC FINES.
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES, PLASTIC FINES.
FINE GRAINED SOILS MORE THAN HALF OF MATERIAL IS SMALLER THAN #200 SIEVE SIZE	SILTS & CLAYS	LIQUID LIMIT IS LESS THAN 50	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY.
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS.
			OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY.
	SILTS & CLAYS	LIQUID LIMIT IS GREATER THAN 50	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS.
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS.
	HIGHLY ORGANIC SOILS		PT	PEAT AND OTHER HIGHLY ORGANIC SOILS.

DEFINITION OF TERMS

GRAIN SIZES

U.S. STANDARD SERIES SIEVE

200 | 50 | 16 | 4 | 3/4" | 3" | 5"

SILTS & CLAYS DISTINGUISHED ON BASIS OF PLASTICITY	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

MOISTURE CONDITION (INCREASING MOISTURE ⟶)

DRY — SLIGHTLY DAMP — DAMP — (PL) — MOIST — VERY MOIST — WET (SATURATED) (LL)

KEY

SAMPLE NUMBER

SAMPLE CONTAINER:

- BAG........... B
- JAR........... J
- SHELBY TUBE... S
- DRIVE SAMPLER RINGS......... R

MODE

METHOD OF ADVANCING HOLE:

DRILL

- FLIGHT AUGER........ AD
- BUCKET AUGER........ BA
- SPIN AUGER.......... SD
- HOLLOW STEM AUGER... HA
- ROTARY DRILL........ RD
- CABLE TOOL.......... CT

SAMPLER

- DRIVE............... DR
- PITCHER BARREL...... PB
- CORE................ C
- PUSH................ P

RECOVERY

RECOVERY RATIO INDICATED BY A FRACTION:

$$\frac{1.2}{1.5} = \frac{\text{FOOTAGE RECOVERED}}{\text{FOOTAGE SAMPLED}}$$

REMARKS

INCLUDES DRILLING INFORMATION, E.G. WATER LEVEL, DATES.

REFUSAL: STOPPED BY MATERIAL TOO HARD FOR EQUIPMENT.

TERMINATED: SUFFICIENT INFORMATION OBTAINED.

ABANDONED: STOPPED BECAUSE OF DIFFICULTIES EXPLAINED ON LOG.

PENETRATION RESISTANCE (PR)
(RECORDED AS BLOWS/0.5 FOOT)

SANDS & GRAVELS

RELATIVE DENSITY	BLOWS/FOOT*
VERY LOOSE	0–4
LOOSE	4–10
MEDIUM DENSE	10–30
DENSE	30–50
VERY DENSE	OVER 50

CLAYS & SILTS

CONSISTENCY	BLOWS/FOOT*	STRENGTH †
VERY SOFT	0–2	0–¼
SOFT	2–4	¼–½
FIRM	4–8	½–1
STIFF	8–15	1–2
VERY STIFF	15–30	2–4
HARD	OVER 30	OVER 4

* Number of blows of 140 pound hammer falling 30 inches to drive a 2 inch O.D. (1-3/8 inch I.D.) Split-Barrel sampler (ASTM-1586 standard penetration test).

† Unconfined compressive strength in tons/sq ft. Read from a pocket penetrometer.

KEY FOR SOIL EXPLORATION LOGS

PROJECT NO. | FIGURE NO.

Best Available Copy

ENCLOSURE

Hole No. 12

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 3 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT 6 Auger
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY PC Exploration	12. MANUFACTURER'S DESIGNATION OF DRILL Mobile B-53
4. HOLE NO. (As shown on drawing title and file number) 12	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 7 bags; UNDISTURBED 2
5. NAME OF DRILLER Mike Moores	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ~~ELEVATION~~ GROUND WATER Depth 22.8' 4/29/87
	16. DATE HOLE — STARTED 4/29/87; COMPLETED 4/29/87
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING. -
9. TOTAL DEPTH OF HOLE 45.0	19. SIGNATURE OF INSPECTOR E. Malcom

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0	CH	LEVEE 0.0 – 15.0 CLAY: dark yellow brown – dusky yellow brown; damp to moist; highly plastic; dessication cracks on surface; stiff; some mottling			Drill w/ 6" hollow stem auger
	2			4 5 6 — 1.4/1.5		1.5-3.0 Standard penetration test (SPT) 140# hammer, 30" drop.
				4 4 5 — 1.2/1.5	B-1	3.0-4.5 SPT.
	4			3 4 5 — 1.2/1.5		4.5-6.0 SPT
	6			4 6 6 — 0.8/1.5		6.0-7.5 SPT.
	8			4 5 6 — 1.1/1.5	B-2	7.5-9.0 SPT
				4 4 6 — 1.5/1.5		9.0-10.5 SPT
	10		9.3-9.5 Med. yel. brown; damp.			
				3 3 5 — 1.5/1.5		10.5-12.0 SPT
	12		11.9-15.0 Some carbonaceous mat'l	3 2 3 — 1.3/1.5		12.0-13.5 SPT
			12.5-15.0 Moist; firm.			
	14			4 3 4 — 1.2/1.5		13.5-15.0 SPT.
			FOUNDATION (?) 15.0 – 22.7 CLAY: olive grey, olive black; moist; mod.-highly plastic; contain abundant, fine-coarse plant remains; firm -	4 4 4 — 1.5/1.5	B-3	15.0-16.5 SPT
	16	CL-CH		1.2/2.5	S-1	16.5-19.0 Push 3" Shelby
	18					
				[illegible]	S-2	19.0-21.5 Push 3" Shelby.
	20					

ENG FORM 1836 [illegible]

ENCLOSURE [illegible]

Hole No. 12

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 12	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20	CL-CH	FOUNDATION (cont'd) 15.0-22.7 CLAY: (cont'd).	1.4/2.5	S-2	19.0-21.5 Push 3" shelby.
	22			3 4 5 — 1.5/1.5	B-3	21.5-23.0 SPT
		CH-OH	FOUNDATION 22.7-29.0 CLAY-ORGANIC CLAY: interbedded w/ peat lenses 0.05' thick; highly plastic; moist-v. moist; firm	3 4 4 — 1.5/1.5	B-4	23.0-24.5 SPT
	24			2 2 3 — 1.5/1.5		24.5-26.0 SPT
	26	CH	25.0-26.0 Clay (CH). dusky yellow brn. moist.			
		CH-OH		3 3 3 — 1.5/1.5		26.0-27.5 SPT
	28			2 2 2 — 1.4/1.5		27.5-29.0 SPT
		CH	29.0-33.5 CLAY: dusky yellow brown; moist; highly plastic; firm-stiff. rare sand grains, 0%-2%.	2 3 3 — 1.1/1.5	B-5	29.0-30.5 SPT
	30			3 3 3 — 1.0/1.5		30.5-32.0 SPT
	32			2 3 3 — 0.6/1.5		32.0-33.5 SPT 32.8 Water on end of sample.
	34	CH, ML	33.5-45.0 INTERBEDDED SILT AND CLAY: mod. yel. brn.-dusky brn. clay; mod.-highly plastic; pale yellow brn.-mod. yel. brn. ML silt; damp-moist; stiff. silt is damp, brittle	4 5 7 — 0.8/1.5	B-6	33.5-35.0 SPT; Sampler wet
				4 4 6 — 0.7/1.5		35.0-36.5 SPT, sampler wet
	36	CH, ML		4 5 5 — 1.3/1.5		36.5-38.0 SPT.
	38			4 5 7 — 1.5/1.5		38.0-39.5 SPT
	40					39.5-41.0 SPT

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE PROJECT

ENCLOSURE

Hole No. 12

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 3 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		CH, ML	FOUNDATION (CONT'D) 33.5 - 45.0 INTERBEDDED CLAY AND SILT, cont'd	5 6 1.3/1.5	B-6	3
		ML	41.0 - 41.4 SILT; wet.	4 4 6 1.3/1.5		41.0 - 42.5 SPT
	42	CH, ML				
				5 5 5 1.0/1.5	B-7	42.5 - 44.0 SPT
	44	CL	44.0 - 45.0 Clay; moist; slightly plastic	4 6 0.6/1.0		44.0 - 45.0 Drive split spoon.
			TOTAL DEPTH 45.0'			45.0 Terminate hole
	46					

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Hole No. 12 A

DRILLING LOG

Field	Entry
DIVISION	
INSTALLATION	
SHEET	1 OF 1 SHEETS
1. PROJECT	
2. LOCATION (Coordinates or Station)	
3. DRILLING AGENCY	PC Exploration
4. HOLE NO. (As shown on drawing title and file number)	12-A
5. NAME OF DRILLER	Mike Moores
6. DIRECTION OF HOLE	[X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	
8. DEPTH DRILLED INTO ROCK	
9. TOTAL DEPTH OF HOLE	20.0
10. SIZE AND TYPE OF BIT	6" Auger
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	Mobile B-53
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED: 2 bags; UNDISTURBED: 2
14. TOTAL NUMBER CORE BOXES	
15. ~~ELEVATION~~ GROUND WATER	DEPTH 12.0' 4/29/87
16. DATE HOLE	STARTED 4/29/87; COMPLETED 4/29/87
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING	%
19. SIGNATURE OF INSPECTOR	E. Solomon

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
	0	CH	0.0 – 11.0 CLAY: dusky yellow brown; moist; highly plastic, stiff; expansion cracks on surface. 0.0 – 0.5' Damp. 3.5' – 9.5 Dark yellow brown.			Drill from w/ 6" hollow stem.
	2			4 / 4 / 5; 1.0/1.5	B-1	1.5 – 3.0 Standard penetration test (SPT); 140# hammer, 30" drop.
				5 / 7 / 8; 1.2/1.5		3.0 – 4.5 SPT
	4			4 / 4 / 4; 1.2/1.5		4.5 – 6.0 SPT
	6			3 / 5 / 5; 1.2/1.5		6.0 – 7.5 SPT
						7.5 End of sample wet.
	8			4 / 4 / 5; 1.5/1.5		7.5 – 9.0 SPT. 8.5 Free water in healed (?) parting in soil
			9.5 – 11.0 - light yellow brown w/ light brown mottling	3 / 4 / 6; 1.2/1.5		9.0 – 10.5 SPT; some moisture on sampler.
	10			3 / 5 / 7; 1.0/1.5		10.5 – 12.0 SPT
		ML-CL	11.0 – 20.0 SILT-CLAY: light yellow brown; damp; slightly plastic; stiff; appears to have been dessicated; decrease in plasticity w/depth.			
	12			5 / 6 / 7; 1.0/1.5	B-2	12.0 – 13.5 SPT; Sampler wet.
				3 / 5 / 6; 0.9/1.5		13.5 – 15.0 SPT; sampler wet; "about 3-feet of water in the hole"
	14			0.4/5.4	S-1	15.0 – 15.4 Push 3" Shelby; refused.
				6 / 7 / 5; 1.1/1.1	B-3	15.4 – 16.5 SPT (?) drove 1.1' only.
	16			1.5/1.5 (?)	S-2	16.5 – 18.0 Push 3" shelby; refused. Liner appears full, slough ?
	18	ML	18.0 Dilatant.	3 / 4 / 5	B-3	18.0 – 19.5 SPT; wet.
	20	SM	19.8 – 19.9 Silty sand.	6		19.5 – 20.0 Drive split spoon. 20.0 Terminate.

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ENCLOSURE

Hole No. - 13

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 2 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY: PC Exploration
4. HOLE NO. (As shown on drawing title and file number): 13
5. NAME OF DRILLER: Mike Moores
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE: 35.5'
10. SIZE AND TYPE OF BIT: 6" Auger
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 6 bags; UNDISTURBED 1
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER: Not Encountered
16. DATE HOLE: STARTED 4/24/87; COMPLETED 4/24/87
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: F. Soloman

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		GP	LEVEE 0.0 - 0.7 GRAVEL: cse.; levee road.			
	2	CL - CH	0.7 - 5.0 CLAY: mottled, dusky yellow brown - mod. yellow brown; damp - moist. mod. - highly plastic; occ. fine - cse. sand.	3 7 6 — 1.4/1.5	B-1	1.5 - 3.0 Standard Penetration Test. (SPT); 140# hammer 30" drop.
	4			4 7 7 — 1.4/1.5		3.0 - 4.5 SPT
				4 7 9 — 1.5/1.5	B-2	4.5 - 6.0 SPT
	6	CL	5.0 - 9.2 CLAY: pale yellow brown - mod. yellow brown; damp - moist; slightly - moderately plastic; occ. fine sand.	4 4 4 — 1.4/1.5		6.0 - 7.5 SPT
	8			4 5 7 — 1.4/1.5		7.5 - 9.0 SPT
	10	CL - CH	9.2 - 17.7 CLAY: mod. yellow brown; moist; mod. - highly plastic; some mottling; internal slicks, parallel, dip 45° - 60°.	3 3 4 — 1.1/1.5	B-3	9.0 - 10.5 SPT
				3 3 3 — 1.0/1.5		10.5 - 12.0 SPT
	12			3 3 5 — 1.2/1.5		12.0 - 13.5 SPT
	14		13.0 - 13.5 V. moist; some carbonaceous mat'l; some rust mottling; mottled	1.6/2.5	S-1	13.5 - 16.0 Push 3" Shelby
	16		16.0 - 17.0 Mottled. 17.0 FOUNDATION 17.0 - 17.7 Some laminae carbonized frag. 17.2 - small shells.	3 3 3 — 1.2/1.5	B-4	16.0 - 17.5 SPT 17.0' Foundation; bioturbation, then some laminae, shells.
	18	CH	17.7 - 22.0 CLAY: olive black; v. moist; highly plastic; ... laminated veg. matter ...	3 3 3 — 1.5/1.5	B-5	17.5 - 19.0 SPT
	20			...		... - 20.5 SPT

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

ENCLOSURE

Hole No. 13

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 2 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 13	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			FOUNDATION (cont'd)	4		
		CH	17.7 – 27.0 CLAY: (cont'd) firm.	3 3 4 — 1.5/1.5	B-5	20.5 – 22.0 SPT
	22		21.6 Decomposed veg. frag. 22.0 – 25.2 2%–5% veg. matter.	2 3 3 — 1.5/1.5		22.0 – 23.5 SPT
	24			3 2 3 — 1.5/1.5		23.5 – 25.0 SPT
	26		25.2 med. grey, silt laminae.	3 3 3 — 1.5/1.5		25.0 – 26.5 SPT
				4 4 6 — 1.5/1.5		26.5 – 28.0 SPT
	28		27.0 – 35.5 CLAY: dusky yel. brn. – dark yel. brn.; moist; stiff; highly plastic; no organic odor.	3 5 7 — 1.5/1.5	B-6	28.0 – 29.5 SPT
	30			3 3 5 — 1.5/1.5		29.5 – 31.0 SPT
	32			4 4 7 — 1.5/1.5		31.0 – 32.5 SPT
				4 5 6 — 1.2/1.5		32.5 – 34.0 SPT
	34			4 4 5 — 1.4/1.5		34.0 – 35.5 SPT; 35.5 Terminate hole; back fill w/cuttings
	36		TOTAL DEPTH 35.5'			

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ENG FORM ... PREVIOUS EDITIONS ARE OBSOLETE — PROJECT

ENCLOSURE -

Hole No. DH-14

DRILLING LOG

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 2 SHEETS

1. PROJECT: West Sac. MA-9 Levee Invest.
2. LOCATION (Coordinates or Station): site #14
3. DRILLING AGENCY: D.C. Exploration
4. HOLE NO. (As shown on drawing title and file number): DH-14
5. NAME OF DRILLER: Mike Moore
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: NA
8. DEPTH DRILLED INTO ROCK: NA
9. TOTAL DEPTH OF HOLE: 35.0
10. SIZE AND TYPE OF BIT: 8" Hollow stem auger
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: Mobile B-53
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 6; UNDISTURBED 1
14. TOTAL NUMBER CORE BOXES: NA
15. ~~ELEVATION~~ GROUND WATER: Not Encountered
16. DATE HOLE: STARTED 4-28-97; COMPLETED 4-28-97
17. ELEVATION TOP OF HOLE: NA
18. TOTAL CORE RECOVERY FOR BORING: NA
19. SIGNATURE OF INSPECTOR: Paul F. Schmidt (WA)

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0	CL	LEVEE 0.0-0.5 Road gravel 0.5-14.8 SANDY CLAY: Dusky yel brn (10YR 2/2); ~90% fines, high plastic, high toughness; ~10% sand, fine-to med.-grained, subrounded and sporatic; charcoal; firm to very stiff; moist.			Sampling with a 2.0" (OD) split spoon sampler, driven by a 140 lb. wire-line hammer, free-fall 30.0 in. per blow
	2.0			2/3/4 1.0/1.5		1.5
				3/5/7 1.4/1.5		3.0
	4.0			3/5/9 1.5/1.5	B-1	4.5
	6.0			4/6/8 1.5/1.5		6.0
	8.0			4/5/8 1.5/1.5		7.5
	10.0			1.7/2.0	S-1	9.0 9.0 pushed shelby
	12.0			3/4/4 1.5/1.5		11.0
			12.5 moisture to damp	3/2/2 1.5/1.5	B-2	12.5
	14.0		FOUNDATION	3/2/2 1.5/1.5		14.0
		CH	14.8-35.0 CLAY: Dk yel brn. to Dk gray (N3); >95% fines, high plastic, high toughness; <5% sand, fine-grained; abundant organics (charcoal and reeds); very abundant Fe mottling; soft; damp. 14.8-15.7 Fe very heavy 15.7 color to Dk. gray only		B-3	15.5
	16.0			2/2/2 1.5/1.5		17.0
	18.0			2/2/2 1.5/1.5	B-4	18.5
				2/2/2 1.5/1.5		

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE PROJECT HOLE NO.

ENCLOSURE

Hole No. DH-14

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 2 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN : DISTURBED : UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.	16. DATE HOLE : STARTED : COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING. %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		CH	14.8-35.0 CLAY: (cont.) organic rich clay continues	2 / 3 / 3 — 1.5 / 1.5		Drilling is stiff — 21.5
	22			2 / 3 / 3 — 1.5 / 1.5	B-4 (cont.)	— 23.0
	24			2 / 2 / 3 — 1.5 / 1.5		— 24.5
			24.8-29.2 large reduction in organics, some caliche now.	2 / 3 / 3 — 1.5 / 1.5		— 26.0
	26			3 / 3 / 3 — 1.5 / 1.5	B-5	— 27.5
	28			2 / 2 / 3 — 1.5 / 1.5		— 29.0
	30		29.2 color to Dk. yel. brn (10YR 4/2); slightly more silty; abundant caliche, gray clay stringers 30.7-30.8' wet zone	2 / 3 / 3 — 1.5 / 1.5		— 30.5
				2 / 3 / 5 — 1.5 / 1.5	B-6	— 32.0
	32			3 / 3 / 2 — 1.5 / 1.5		— 33.5
	34		Bottom Hole 35.0	2 / 2 / 4 — 1.5 / 1.5		— 35.0
						Terminated boring at 35.0' (required depth) and back-filled hole with cuttings.

Hole No. 14 A

DRILLING LOG

Field	Entry
DIVISION	
INSTALLATION	
SHEET	1 OF 1 SHEETS
1. PROJECT	
2. LOCATION (Coordinates or Station)	
3. DRILLING AGENCY	PC Exploration
4. HOLE NO. (As shown on drawing title and file number)	14 A
5. NAME OF DRILLER	Mike Moore
6. DIRECTION OF HOLE	[X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	
8. DEPTH DRILLED INTO ROCK	
9. TOTAL DEPTH OF HOLE	20.0
10. SIZE AND TYPE OF BIT	6-inch auger
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	Mobile B-53
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED: 8 bags; UNDISTURBED: 3
14. TOTAL NUMBER CORE BOXES	
15. ELEVATION GROUND WATER	Not Encountered
16. DATE HOLE	STARTED: 4/29/87; COMPLETED: 4/29/87
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING	%
19. SIGNATURE OF INSPECTOR	F. Solomon

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		CL-CH	0.0 - 20.0 CLAY: mod. - dusky yellow brown; damp - moist; mod. - highly plastic; roots to 1.0'. moisture increases w/ depth			Drill w/ 6" hollow-stem.
	2			4 4 5; 1.2/1.5		1.5 - 3.0 Standard penetration Test (SPT); 140# hammer, 30" drop.
			3.0 - 6.5 Sandy	4 4 4; 1.2/1.5	B-1	3.0 - 4.5 SPT
	4			3 5 5; 1.4/1.5		4.5 - 6.0 SPT
	6			4 6 7; 1.5/1.5		6.0 - 7.5 SPT
	8			1.0/2.0	S-1	7.5 - 9.5 Push 3" shelby
			9.5 moist; some carbonaceous mat'l.			
	10			1.0/2.0	S-2	9.5 - 11.5 Push 3" Shelby.
			11.5 V. moist.			Ream and clean hole to 11.5'.
	12			3 4 4; 1.5/1.5		11.5 - 13.0 SPT
				3 3 3; 1.2/1.5	B-2 (1 of 2)	13.0 - 14.5 SPT
	14		14.5 Root(?) holes.	3 3 4; 1.4/1.5	(2 of 2)	14.5 - 16.0 SPT
	16		16.0 - V. moist	2 2 4; 1.4/1.5		16.0 - 17.5 SPT
			17.5 V. moist			
	19			2.5/2.5	S-3	17.5 - 20.0 Push 3" Shelby
	20		20.0 v. moist - wet; mod. yel. brn; some caliche 20.0' total			20.0 Terminate hole

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ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

ENCLOSURE

Hole No. DH-15

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 2 SHEETS

1. PROJECT: West Sac. MA-9 Levee Invest.	10. SIZE AND TYPE OF BIT: 8.0" Hollow stem auger
2. LOCATION (Coordinates or Station): Sac River Deep Water Channel, East Levee 3+18	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: P.C. Exploration	12. MANUFACTURER'S DESIGNATION OF DRILL: Mobile B-53
4. HOLE NO. (As shown on drawing title and file number): DH-15	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 5; UNDISTURBED 2
5. NAME OF DRILLER: Mike Moore	14. TOTAL NUMBER CORE BOXES: NA
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ~~ELEVATION~~ Depth to GROUND WATER: Not Encountered
	16. DATE HOLE: STARTED 4-28-87; COMPLETED 4-28-87
7. THICKNESS OF OVERBURDEN: NA	17. ELEVATION TOP OF HOLE: NA
8. DEPTH DRILLED INTO ROCK: NA	18. TOTAL CORE RECOVERY FOR BORING: NA %
9. TOTAL DEPTH OF HOLE: 35.0	19. SIGNATURE OF INSPECTOR: Paul J. Schmidt (WA)

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0	CL	LEVEE 0.0 - 16.2 SANDY CLAY: Dk. yel brn (10 YR 4/2); ~80% Fines, mod to high plastic, mod to high toughness; ~20% sand, fine-grained; charcoal; Fe staining; gray clay stringers and small holes (burrows); Firm to stiff; moist			Sampling with a 2.0" (OD) split spoon sampler, driven by a 140 lb. wire-line hammer, Free-Falling 30.0" per blow.
	2.0			3 3 3 — 0.8/1.5	B-1	1.5 – 3.0
	4.0			4 4 5		3.0 – 4.5
	6.0			0.8/2.5	S-1	4.5 – 7.0
	8.0			1.2/2.5	S-2	7.0 – 9.5
	10.0		9.5' - 16.0 caliche present, charcoal streaks	4 4 5 — 1.4/1.5		9.5 – 11.0
	12.0			3 2 3 — 1.2/1.5		11.0 – 12.5
			12.7 - 13.6 abundant white ppt. (soft).	3 4 4 — 1.5/1.5	B-2	12.5 – 14.0
	14.0			5 5 5 — 1.5/1.5		14.0 – 15.5
	16.0	CH	FOUNDATION 16.2 - 35.0 CLAY: Dk yel. brn (10 YR 4/2); >95% Fines, high plastic, high toughness; <5% sand, fine-grained; charcoal specks; slight caliche; Firm; moist. 16.2 - 16.4 roots	3 4 7 — 1.5/1.5		15.5 – 17.0 Drilling is getting hard.
	18.0			3 3 4 — 1.5/1.5	B-3	17.0 – 18.5
	20.0			3 4 4 — 1.3/1.5		18.5 –

ENCLOSURE 7

Hole No. DH-15

DRILLING LOG

DIVISION	INSTALLATION	SHEET 2 OF 2 SHEETS

1. PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE
☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0	CH	16.2-35.0 CLAY: (cont.) 20.4' some yellowish; gray clay stringers	3, 4, 5 — 1.5/1.5	B-3 (cont.)	21.5
	22.0			4, 5, 6 — 1.4/1.5		23.0
			23.0-24.0 very stiff clay, no rxn to HCL.	5, 5, 7 — 1.5/1.5	B4	24.5
	24.0			5, 6, 9 — 1.5/1.5		26.0
	26.0		25.5-30.5 abundant caliche, very stiff to hard.	5, 5, 14 — 1.5/1.5		27.5 Drilling is getting very hard.
	28.0			6, 10, 13 — 1.2/1.5		29.0
	30.0			4, 6, 6 — 1.1/1.5		30.5
			30.5-35.0 reduction in caliche, stiff	8, 9, 12 — 1.4/1.5	B-5	32.0
	32.0			8, 8, 11 — 1.1/1.5		33.5
	34.0			3, 5, 9 — 1.2/1.5		35.0
			Bottom Hole 35.0			
	36.0					Terminated boring at 35.0' and back-filled hole with cuttings.

[illegible]

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

ENCLOSURE

Hole No. DH-15A

DRILLING LOG

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT	West Sac., MA-9 Levee Invest.
2. LOCATION (Coordinates or Station)	
3. DRILLING AGENCY	P.C. Exploration
4. HOLE NO. (As shown on drawing title and file number)	DH-15A
5. NAME OF DRILLER	Mike Moore
6. DIRECTION OF HOLE	☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	NA
8. DEPTH DRILLED INTO ROCK	NA
9. TOTAL DEPTH OF HOLE	20.0
10. SIZE AND TYPE OF BIT	8.0" Hollow stem augers
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	Mobile B-53
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED: 4 ; UNDISTURBED: 1
14. TOTAL NUMBER CORE BOXES	
15. ~~ELEVATION~~ DEPTH TO GROUND WATER	Not Encountered
16. DATE HOLE	STARTED: 4-28-87 ; COMPLETED: 4-28-87
17. ELEVATION TOP OF HOLE	NA
18. TOTAL CORE RECOVERY FOR BORING	NA %
19. SIGNATURE OF INSPECTOR	Paul J. Schmidt

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		FOUNDATION			Sampling with a 2.0" (OD) split spoon sampler, driven by a 140 lb wire-line hammer, free-falling 30 in per blow.
		SP	0.0 - 0.5 hard pan road			
			0.5 - SILTY SAND:			
	1.5–3.0		Salt & pepper; ~30% fines, non to slight plasticity; ~70% very fine- to medium-grained sand, qtz, mica flakes; high perviousness; loose; moist to wet.	3, 4, 5 — 1.0/1.5		1.5
	2.0					
	3.0–4.5			5, 5, 8 — 1.4/1.5	B-1	3.0
	4.0		4.0-4.2 clayey lens			
	4.5–6.0			4, 4, 4 — 1.1/1.5		4.5
			5.5' wet			
	6.0–7.5			2, 1, 1 — 0.5/1.5		6.0
	7.5–9.0	CH	7.7 - 20.0 CLAY: Dk grn-gray (5GY4/1); >95% fines, high plastic, high toughness; <5% sand, fine-grained; abundant roots, charcoal; soft; wet.	2, 1, 2	B-2	7.5
	8.0					
	9.0–11.0			0.9/2.0	S-1	9.0
	10.0					
	11.0–12.5			3, 4, 5 — 1.5/1.5		11.0
	12.0					
	12.5–14.0			4, 4, 5 — 1.5/1.5	B-3	12.5
	14.0–15.5		14.5 change in color to Dk yel brn (10YR 4/2); abundant caliche, charcoal specks	4, 4, 4 — 1.5/1.5		14.0
	15.5–17.0			5, 4, 4 — 1.1/1.5		15.5
	16.0					Terminated boring at 20.0' and back filled hole with cuttings.
	17.0–18.5			5, 5, 5 — 1.5/1.5	B-4	17.0
	18.0					
	18.5–20.0			5, 5, 5 — 1.5/1.5		18.5
	20.0		Bottom Hole 20.0			20.0

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SOIL CLASSIFICATIONS SHOWN ON LOGS ARE FIELD CLASSIFICATIONS BASED ON THE UNIFIED SOILS CLASSIFICATION SYSTEM.

BORING LOCATION RD-900 Unit 2, Levee Mile 0.45, 15' south of waterside ...			GROUND EL.
DEPTH/ELEV. WATER wet soil @ 29.5'	DRILL CONTRACTOR D.C. Exploration		TOTAL DEPTH 34.0'
DRILL RIG Mobile B-53	BORING DIA. 6"	DATE DRILLED 8/10/89	LOGGED BY RH

SOIL CLASS.	DESCRIPTION	DEPTH	SAMPLE NO.	PR/RQD	REC.	MODE	REMARKS
	LEVEE	0					0'-32.5' Advance hole w/ 6" hollow stem augers.
GP	0'-~1' SANDY GRAVEL					HA	
CL-CH	1'-15.7' CLAY: dk. brown-gray, some yllwsh brown (silty clay); slightly damp; firm-stiff; mod-highly plastic; minor f. sand; occ. charcoal flecks.	2					2.5'-34.0' Continuous Standard Penetration Test; 140# hammer, 30" drop
			B-1	3 3 5	1.2/1.5	DR	
	-damp from ~5' to 9'	4	B-2	3 3 5	.3/1.5		
	-soft to firm from 5.5' to 8'	6	B-3	2 2 2	.7/1.5		
	-stiff from 8' to 11.5'	8	B-4	2 2 4	.3/1.5		
	-moist from 9' to 12.5'		B-5	3 4 5	.7/1.5		
	-firm from 11.5' to 15.7'	10	B-6	3 4 5	.9/1.5		Note: move hole 3' west upon completion, drill to 12' for shelby tube sampling
	-slicks on vertical fracture @ 12.2' -v. moist from 12.5' to 15.7'	12	B-7	2 3 4	1.3/1.5	1.3/2.0 P (S-1)	12.0'-14.0' Push 3" Shelby - easy push; poor recovery
CL	-silty clay, yllwsh. brown mottled orange; v. moist to wet, v. soft, low plast. from 13.4'-13.6'		B-8	2 3 3	1.0/1.5		
CL-CH		14					
CL	-½" orange silty clay, appears soft, @ 15.1'		B-9	2 2 3	1.5/1.5	1.3/2.0 P (S-2)	14.0'-16.0' Push 3" Shelby - easy push, slightly dented tube
CL-CH	FOUNDATION						
CH	15.7'-29.5' CLAY: dk. gray-black; v. moist; firm; highly plastic; mod. organic (occ. black rootlets, fine wood flecks-carbonized); occ. faint orange mottling; minor f. sand.	16	B-10	2 2 3	1.5/1.5	1.7/2.0 P (S-3)	16.0'-18.0' Push 3" Shelby - easy push
		18	B-11	1 2 3	.6/1.5		
	-yllwsh. brown, mottled gray (inorganic) from 19.4'-20.0'	20	B-12	2 3	1.5/1.5		

BORING LOCATION			GROUND EL.
DEPTH/ELEV. WATER	DRILL CONTRACTOR		TOTAL DEPTH
DRILL RIG	BORING DIA.	DATE DRILLED	LOGGED BY

SOIL CLASS.	DESCRIPTION	DEPTH	SAMPLE NO.	PR / ROD	REC.	MODE	REMARKS
CH	15.7'-29.5' Clay (cont.)	20	B-12	3	1.5/1.5	DR	2.5'-34.0' Continuous SPT (cont.)
	- soft to firm from 20.5' to 22'		B-13	1 2 2	1.5/1.5		
	- firm from 22' to 23.5' - soft-firm from 23.5'-25.5'	22	B-14	2 2 3	1.0/1.5		
	- dk. brown-gray from 23.7' to 25.5'	24	B-15	2 2 2	.4/1.5		- drill addendum hole to 25.5' for Shelby tube sampling
	- firm from 25.5' to 28'	26	B-16	2 3 4	1.5/1.5	1.3 / 2.3 P (3-4)	25.5'-27.8' Push 3" Shelby
OH	- highly organic from 26.7' to 27.8		B-17	1 3 3	1.5/1.5		- easy push
CH	- moist from 27.8' to 29.5' - soft (?) from 28'-29'; possibly stiff from 29'-29.5' (?) - probably stiff from 28'-29.5' *	28	B-18	1* 1 6	.7/1.5		*- recovered sample appears stiff (low blows from 28'-29' may have been through over-lying slough)
CL-CH	29.5'-34.0' CLAY: yllwsh. brown, motiled gray; v. moist to wet; firm to stiff; mod-highly plastic; occ. free water (wet film along root voids); trace v.f. sand; occ. charcoal	30	B-19	3 3 5	1.5/1.5		
	- stiff from 31' to 34'	32	B-20	3 5 7	1.5/1.5		
			B-21	3 5 7	1.5/1.5		Terminate @ 34.0'
	END OF BORING @ 34.0'	34					Backfill w/cuttings
		36					
		38					
		40					

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Wahler Associates	SRFCP LEVEE RECONSTRUCTION	EXPLORATION BORING LOG	BORING NO.
		PROJECT NO. 6E-233 A1 / SHEET NO. 2 OF 2	DH-14-1

ENCLOSURE

BORING LOCATION RD-900 Unit 2 Levee Mile 0.57 18' south of waterside edge of crown			GROUND EL.
DEPTH/ELEV. WATER saturated soil @ 17'	DRILL CONTRACTOR DC Exploration		TOTAL DEPTH 33.5'
DRILL RIG Mobile B-53	BORING DIA. 6"	DATE DRILLED 8/11/89	LOGGED BY RH

SOIL CLASS.	DESCRIPTION	DEPTH	SAMPLE NO.	PR/RQD	REC.	MODE	REMARKS
	LEVEE	0					0'-32.0' Advance w/6" hollow stem augers.
GP	0'-1' SANDY GRAVEL					HA	
CL-CH	1'-17' CLAY: dk. gray-brown; some yllwsh. brown (silty clay-CL); damp; v. stiff; mod.-high plasticity; minor f. sand.	2	B-1	6 7 9	.5/1.5	DR	2.0'-33.5' Continuous Standard Penetration Test; 140# hammer, 30" drop.
	-v. soft from 3.5' to 5'	4	B-2	1 1 1	.4/1.5		
	-moist from 5' to 11' -firm to stiff from 5'-6.5'	6	B-3	2 3 5	.6/1.5		
	-firm from 6.5' to 8'		B-4	2 3 3	.5/1.5		
	-stiff from 8' to 11'	8	B-5	2 4 5	.9/1.5		
CL	-yllwsh. brown clay, mod. plastic, from 9.5' to 11'	10	B-6	2 4 5	1.3/1.5		Note: move hole west, drill to 12' for undisturbed, shelby tube sampling.
CL-CH	-firm from 11' to 16' -v. moist from 11' to 17'	12	B-7	1 2 4	1.2/1.5	1.4/2.0	12.0'-14.0' Push 3" Shelby
	[illegible]		B-8	1 2 3	.8/1.5	P (E-A)	
	-dk. gray-black, mod. organic from 14.5'-15.0'	14	B-9	1 2 3	1.5/1.5	1.7/2.0 P (S-1)	14.0'-16.0' Push 3" Shelby. -easy push
CL	-yllwsh. brown from 15.5'-15.8'						
CL-CH	-stiff from 16'-17'	16	B-10	2 3 6	.3/1.5	1.8/2.0 P	16.0'-18.0' Push 3" Shelby -easy push
	FOUNDATION						
CH	17'-30' CLAY: dk. gray-black; saturated; firm; highly plastic; mod. organic; trace of f. sand; occ. greenish gray mottling; occ. faint orange mottling. - mottled yllwsh. brown-gray from 19'-20'	18	B-11	1 3 4	.3/1.5	(S-6) 1.2/2.0	18.0'-20.0' Push 3" Shelby
			B-12	1 2 3	1.4/1.5	P (S-2)	-easy push
		20					

Woodward-Clyde Consultants — SRFCP LSIP RECONSTRUCTION

EXPLORATION BORING LOG — PROJECT NO. [illegible] — SHEET NO. 1 OF 2 — BORING NO. DH-10-2

ENCLOSURE

BORING LOCATION		GROUND EL.
DEPTH/ELEV. WATER	DRILL CONTRACTOR	TOTAL DEPTH
DRILL RIG / BORING DIA.	DATE DRILLED	LOGGED BY

SOIL CLASS.	DESCRIPTION	DEPTH	SAMPLE NO.	PR / RQD	REC.	MODE	REMARKS
CH	17'-25.0' Clay (cont.)	20	B-13	1 2 3	1.1/1.5	1.8/2.0 P (S-C)	20'-33.5' Continuous SPT - easy push (cont.) 20.0'-22.0' Push 3" Shelby
CH-OH	- mod.-highly organic from 21.5' to 22'	22	B-14	1 2 3	1.2/1.5		
CH		24	B-15	1 2 3	1.5/1.5	DR	
			B-16	1 2 3	.7/1.5		
OH	- highly organic w/ peat lenses, soft-firm, from 26.3' to 27.5'	26	B-17	2 2 2	.7/1.5	1.7/1.7 P (S-3)	26.0'-27.7' Push 3" Shelby - easy push
CH	28.0'-33.5' CLAY: dk. gray-brown; v. moist - saturated; stiff; highly plastic; trace of f. sand; v. fine orange mottling; occ. charcoal flecks; occ. free water (film) along ~~root~~ voids.	28	B-18	3 4 5	1.5/1.5	1.9/2.0 P (S-0)	28.0'-30.0' Push 3" Shelby
		30	B-19	4 5 6	1.5/1.5		
	- mottled yellowish brown/gray from 30.5' to 33.5' - firm (?)* from 30.5'-32'		B-20	2* 3 3	.4/1.5		- recovered mainly slough from 30.5'-32' (lower blows possibly from driving through slough)
	- v. stiff from 32'-33.5'	32	B-21	5 6 9	1.5/1.5		Terminate @ 33.5'
	END OF BORING @ 33.5'	34					Backfill w/ cuttings
		36					
		38					
		40					

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Wahler Associates	SRFCP LEVEE RECONSTRUCTION	EXPLORATION BORING LOG — PROJECT NO. COE-263H — SHEET NO. 2 OF 2	BORING NO. DH-14-2

ENCLOSURE 10

BORING LOCATION RD-900 Unit 2 Levee Mile 0.70 15' south of waterside edge on crown			GROUND EL.
DEPTH/ELEV. WATER v. moist-wet soil @ 16.5'; no free water	DRILL CONTRACTOR PC Exploration		TOTAL DEPTH 32.0'
DRILL RIG Mobile B-53	BORING DIA. 6"	DATE DRILLED 9/11/89	LOGGED BY RH

SOIL CLASS.	DESCRIPTION	DEPTH	SAMPLE NO.	PR/ROD	REC.	MODE	REMARKS
	LEVEE	0					0'-30.5' Advance hole w/ 6" hollow stem augers.
GP	0'-~1' SANDY GRAVEL						
CL	~1'-13.5' SILTY CLAY: yllwsh. brown; occ. dk. brown-gray (CL-CH); damp; v. stiff; mod. plast.; minor f. sand; occ. hard, coarse sand-size fragments (caliche?).					HA	
		2	B-1	5 7 10	.6/1.5	DR	2.0'-9.5' Continuous Standard Penetration Test (SPT), 140# hammer, 30" drop
	- stiff from 3.5' to 6.5' - moist from ~4' to 13.5'	4	B-2	3 4 5	1.5/1.5		
		6	B-3	3 4 4	.6/1.5		
CL-CH	- dk. brown-gray, mod-high plast., from 6.5' to 7' - soft from 6.5' to 8.5'		B-4	2 1 1	.7/1.5		
CL	- Firm from 8.5' to 13.5'	8	B-5	1 2 3	.7/1.5		
		10	S-1		1.5/2.0	P	9.5'-11.5' Push 3" Shelby. - easy push
CL-CH	- dk. gray brown, mod-high plast., from ~10.5' to 11.7'						
CL		12	B-6	2 3 3	.8/1.5	DR	11.5'-17.5' Continuous SPT.
CH	13.5'-16.5' CLAY: dk. gray-brown; moist-v. moist; firm; high plast.; occ. yllw brn. clay (CL); minor sand.	14	B-7	1 3 3	1.2/1.5		
	- Firm to stiff from 15' to 16' FOUNDATION		B-8	2 3 5	1.1/1.5		
CH	16.5'-28.2' CLAY: dk. gray-black; v. moist-wet; firm; highly plastic; mod. organic.	16	B-9	2 3 3	1.2/1.5		
		18	S-2		1.5/1.7	P	17.5'-19.2' Push 3" Shelby - easy push
	- dk. grey brown @ 19'					LA	- drill out to 19.5'
		20	B-10	2	1.2/1.5	DR	19.5'-20.0' Continuous SPT.

Wahler Associates	SRFCP LEVEE RECONSTRUCTION	EXPLORATION BORING LOG PROJECT NO. CAE-263A / SHEET NO. 1 of 2	BORING NO. DH-14-3

ENCLOSURE 11

BORING LOCATION		GROUND EL.
DEPTH/ELEV. WATER	DRILL CONTRACTOR	TOTAL DEPTH
DRILL RIG	BORING DIA. / DATE DRILLED	LOGGED BY

SOIL CLASS.	DESCRIPTION	DEPTH	SAMPLE NO.	PR / 300	REC.	MODE	REMARKS
CH	16.5'-28.2' Clay (cont.) – dk. gray brown from 20.4' to 21.3'	20	B-10	2 5	1.2/1.5	DR	19.5'-24.0' Continuous SPT (cont.)
		22	B-11	2 3 5	1.5/1.5		
	– occ. peat pockets to ½"⌀, from 22.5' to ~25'		B-12	1 2 3	1.3/1.5		
		24	S-3		1.5/1.8	P	24.0'-25.8' Push 3" Shelby.
	– numerous root voids, mod.-highly plastic @ 25.5'						– drill out to 26'
	– slightly organic from ~26' to 28.2'	26	B-13	2 4 5	.5/1.5	DR	26.0'-32.0' Continuous SPT
	– stiff from 26.5' to 27.5'						
CH	28.2'-31.2' CLAY: dk gray-brown; moist-v. moist; firm; highly plastic.	28	B-14	2 3 4	1.5/1.5		
		30	B-15	3 3 3	1.4/1.5		
CL-CH	31.2'-32' CLAY: yellowish-brown, mottled gray; moist-v. moist, stiff; mod.-highly plastic.		B-16	3 5 8	.5/1.5		Terminate @ 32.0'
	END OF BORING @ 32.0'	32					Backfill w/cuttings.
		34					
		36					
		38					
		40					

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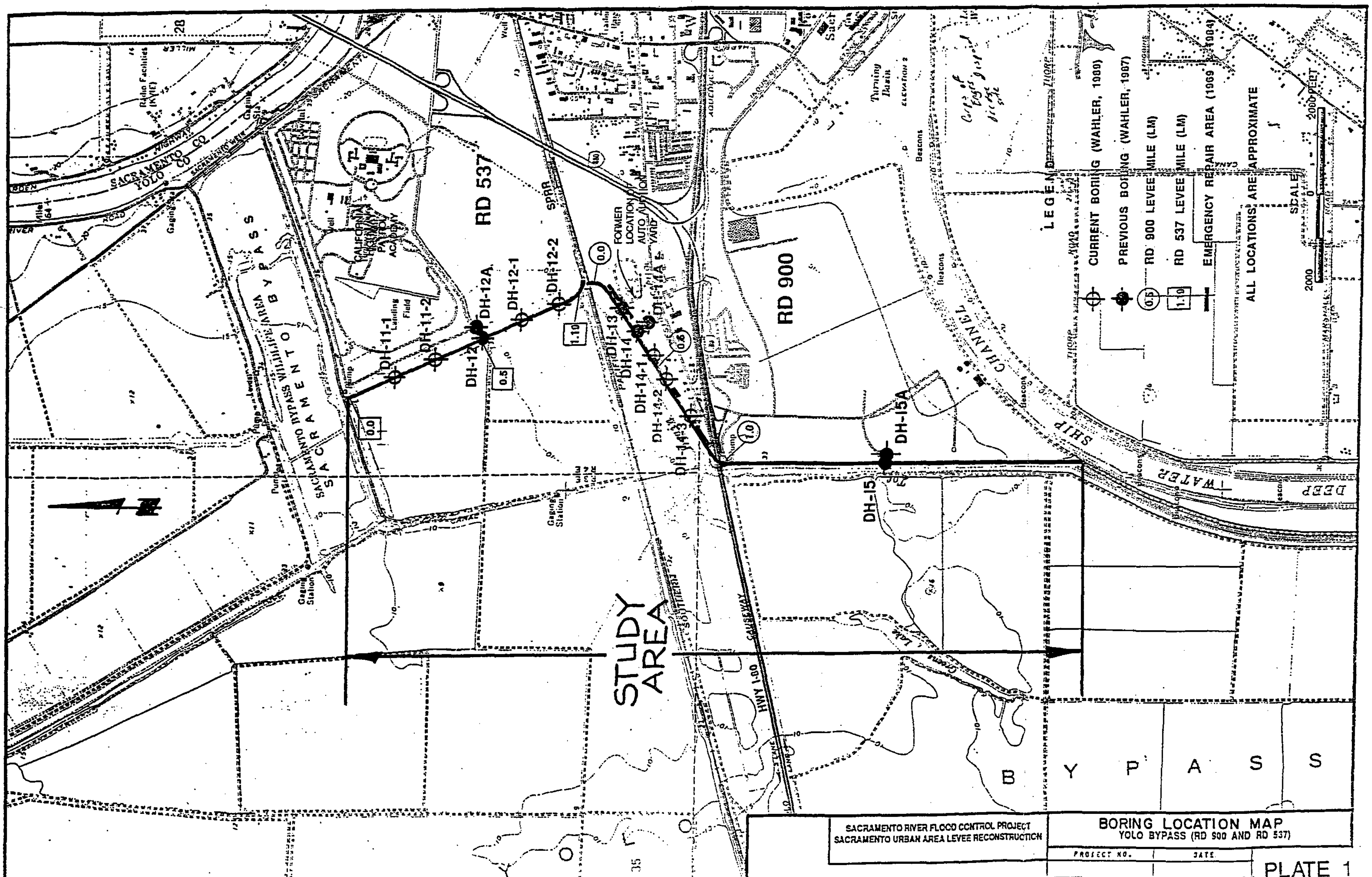
THE STRATIFICATION LINES OR DEPTH INTERVALS REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN MATERIAL TYPES, AND THE TRANSITIONS MAY BE GRADUAL.

SOIL CLASSIFICATIONS SHOWN ON LOGS ARE FIELD CLASSIFICATIONS BASED ON THE UNIFIED SOILS CLASSIFICATION SYSTEM.

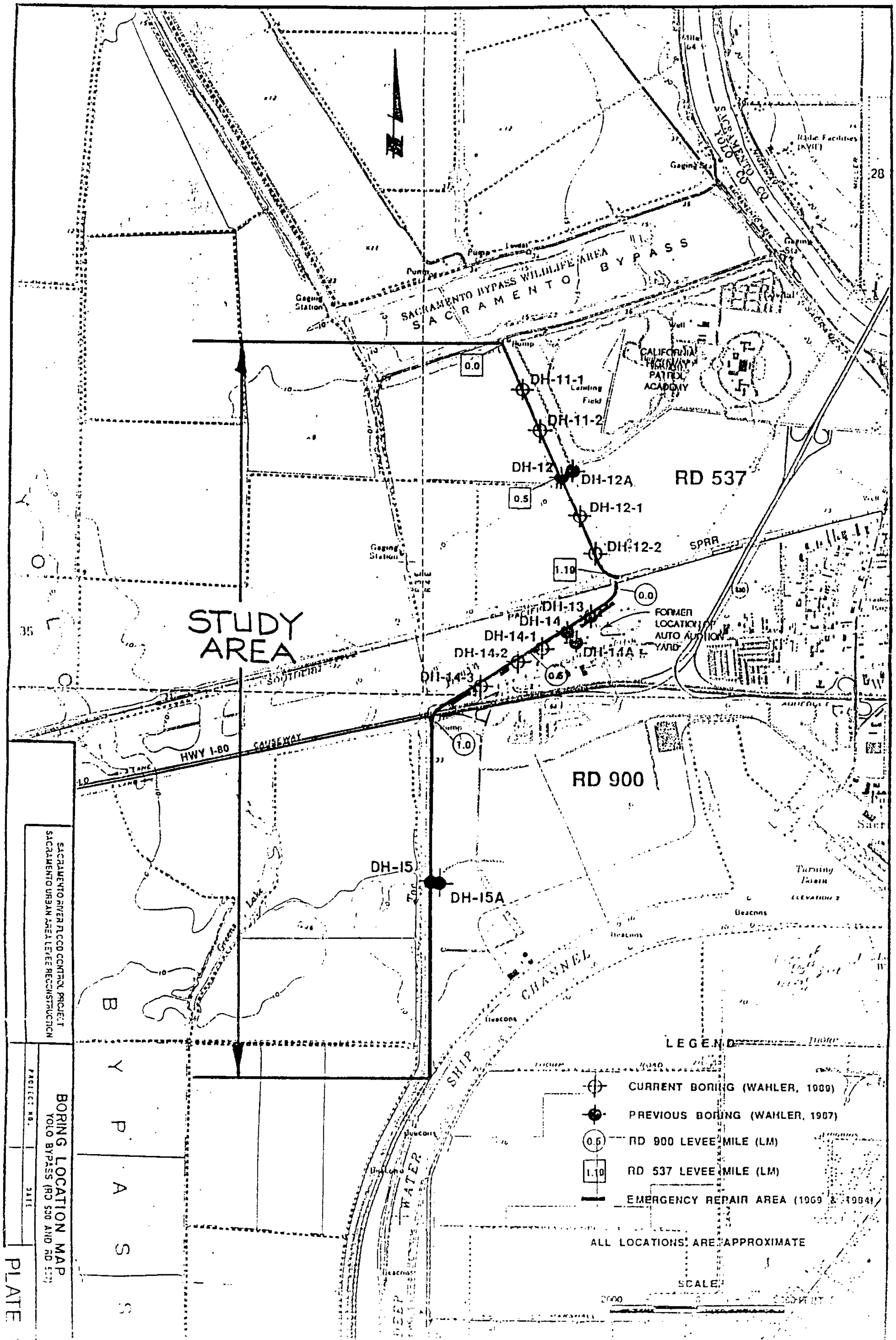
Wahler Associates	SRFCP LEVEE RECONSTRUCTION	EXPLORATION BORING LOG — PROJECT NO. 106-203A — SHEET NO. 2 OF 2	BORING NO. D4-4-3

ENCLOSURE

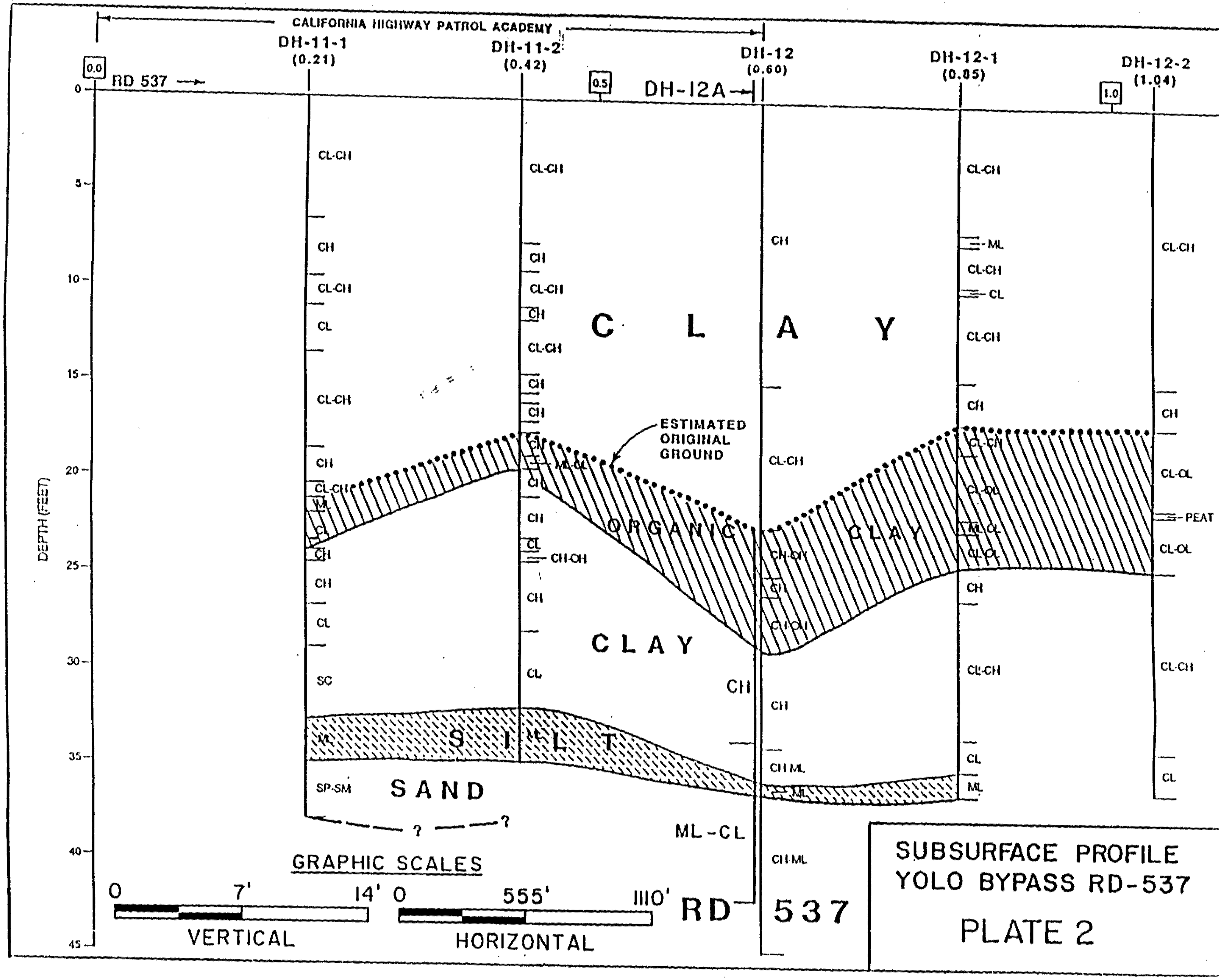

LEGEND
CURRENT BORING (WAHLER, 1989)
PREVIOUS BORING (WAHLER, 1987)
RD 900 LEVEE MILE (LM)
RD 537 LEVEE MILE (LM)
EMERGENCY REPAIR AREA (1969 - 1984)
ALL LOCATIONS ARE APPROXIMATE
SCALE
0
2000
2000 FEET
RD 537
RD 900
STUDY AREA
DEEP WATER SHIP CHANNEL
SACRAMENTO BYPASS
SACRAMENTO BYPASS WILDLIFE AREA
YOLO BYPASS
CALIFORNIA HIGHWAY PATROL ACADEMY
FORMER LOCATION OF AUTO AUCTION YARD
DH-11-1
DH-11-2
DH-12
DH-12A
DH-12-1
DH-12-2
DH-13
DH-14
DH-14A
DH-14-1
DH-14-2
DH-14-3
DH-15
DH-15A
0.0
0.5
1.0
1.10
SPRR
HWY I-80
CAUSEWAY
SOUTHERN PACIFIC
Turning Basin
Beacons
Gaging Station
Pump
Radio Facilities (KYIE)
SACRAMENTO YOLO CO CO
28
35
SACRAMENTO RIVER FLOOD CONTROL PROJECT
SACRAMENTO URBAN AREA LEVEE RECONSTRUCTION
BORING LOCATION MAP
YOLO BYPASS (RD 900 AND RD 537)
PROJECT NO.
DATE
PLATE 1

PLATES

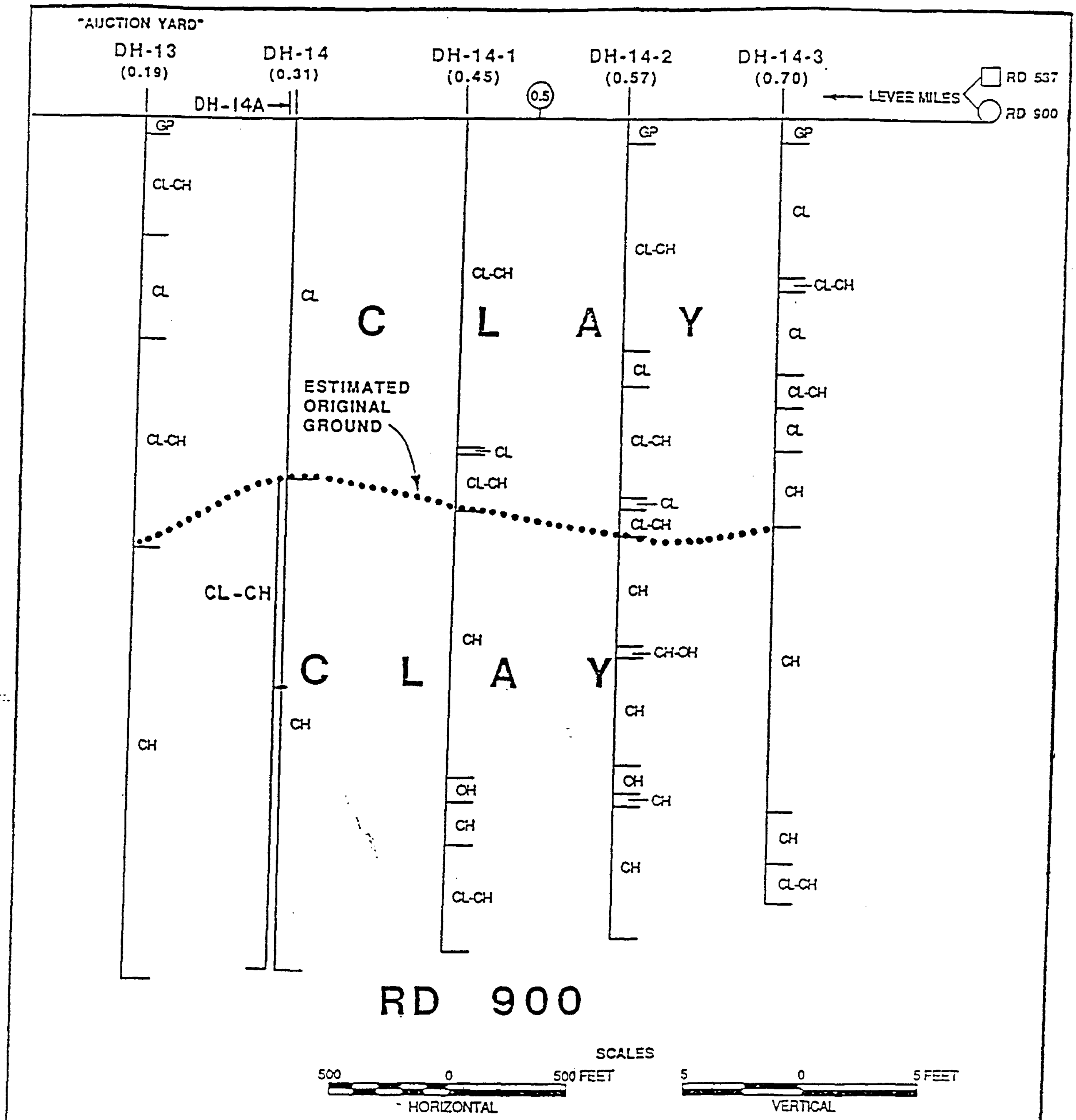
PLATES



STUDY AREA
SACRAMENTO BYPASS
SACRAMENTO BYPASS WILDLIFE AREA
CALIFORNIA HIGHWAY PATROL ACADEMY
RD 537
RD 900
SPRR
HWY I-80 CAUSEWAY
FORMER LOCATION OF AUTO AUCTION YARD
DH-11-1
DH-11-2
DH-12
DH-12A
DH-12-1
DH-12-2
DH-13
DH-14
DH-14-1
DH-14-2
DH-14-3
DH-14A
DH-15
DH-15A
0.0
0.5
1.10
1.0
SHIP CHANNEL
YOLO BYPASS
LEGEND
CURRENT BORING (WAHLER, 1989)
PREVIOUS BORING (WAHLER, 1987)
RD 900 LEVEE MILE (LM)
RD 537 LEVEE MILE (LM)
EMERGENCY REPAIR AREA (1969 & 1984)
ALL LOCATIONS ARE APPROXIMATE
SCALE
SACRAMENTO RIVER FLOOD CONTROL PROJECT
SACRAMENTO URBAN AREA LEVEE RECONSTRUCTION
BORING LOCATION MAP
YOLO BYPASS (RD 900 AND RD 537)
PROJECT NO.
DATE
PLATE 1



CALIFORNIA HIGHWAY PATROL ACADEMY
DH-11-1 (0.21)
DH-11-2 (0.42)
DH-12 (0.60)
DH-12A
DH-12-1 (0.85)
DH-12-2 (1.04)
RD 537
0.0
0.5
1.0
DEPTH (FEET)
CLAY
ORGANIC CLAY
CLAY
SILT
SAND
ESTIMATED ORIGINAL GROUND
CH
ML-CL
SP-SM
SC
PEAT
GRAPHIC SCALES
VERTICAL
HORIZONTAL
0 7' 14'
0 555' 1110'
RD 537
SUBSURFACE PROFILE
YOLO BYPASS RD-537
PLATE 2



Wahler Associates

SACRAMENTO RIVER FLOOD CONTROL PROJECT
SACRAMENTO URBAN AREA LEVEE RECONSTRUCTION

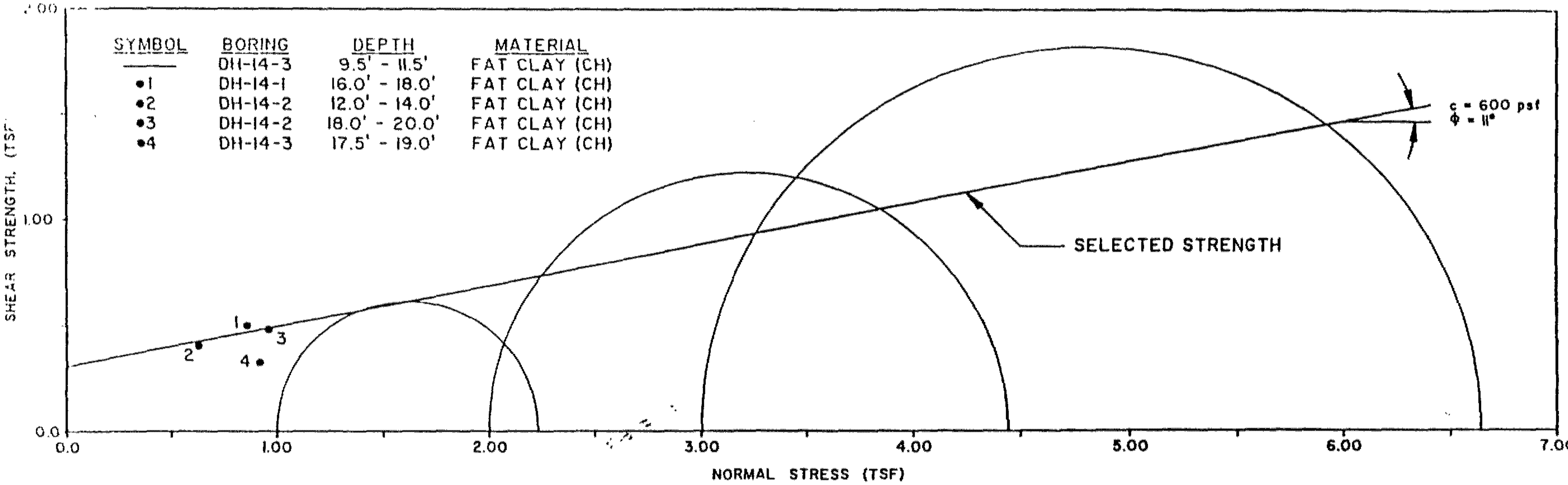
PALO ALTO • CALIFORNIA

SUBSURFACE PROFILE
YOLO BYPASS RD 900

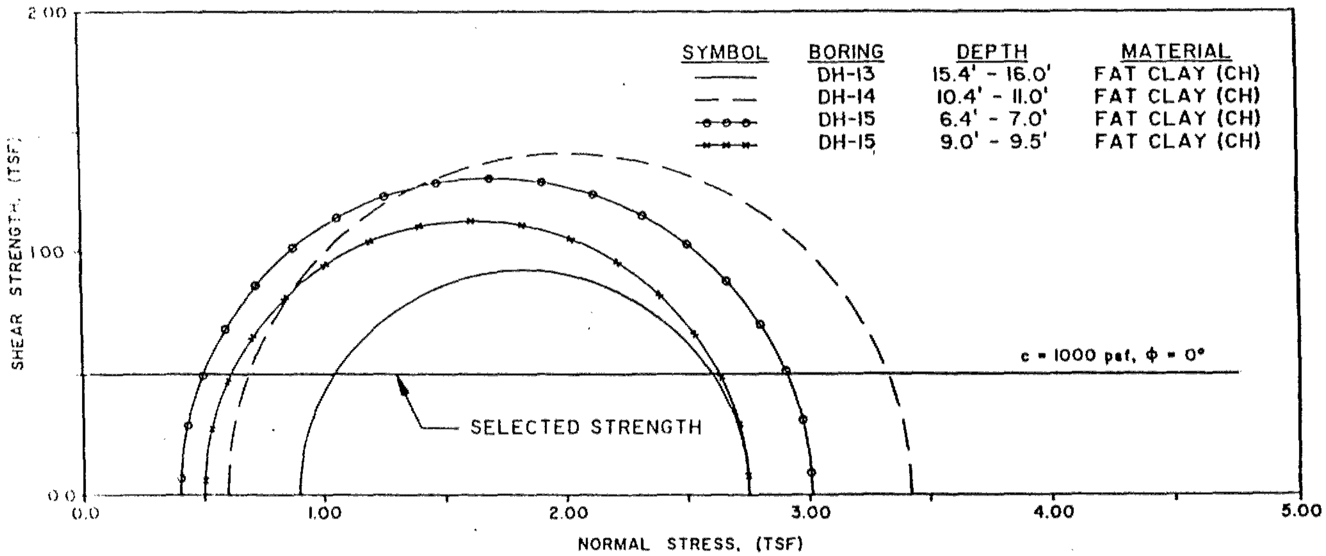
PROJECT NO.	DATE	FIGURE NO.

PLATE 2.1

UNCONFINED COMPRESSION (UC) AND CONSOLIDATED - UNDRAINED (R) TRIAXIAL COMPRESSION TESTS



UNCONSOLIDATED - UNDRAINED (Q) TRIAXIAL COMPRESSION TESTS



NOTE:

1. UNCONFINED COMPRESSION TEST RESULTS (1,2,3 & 4) ARE APPROXIMATELY EQUAL TO CONSOLIDATED-UNDRAINED TESTS ON THE SAME CLAY UNDER CONFINING PRESSURE σ_3, WHERE $\sigma_3 \approx 0.9\,\bar{\sigma}_v$.

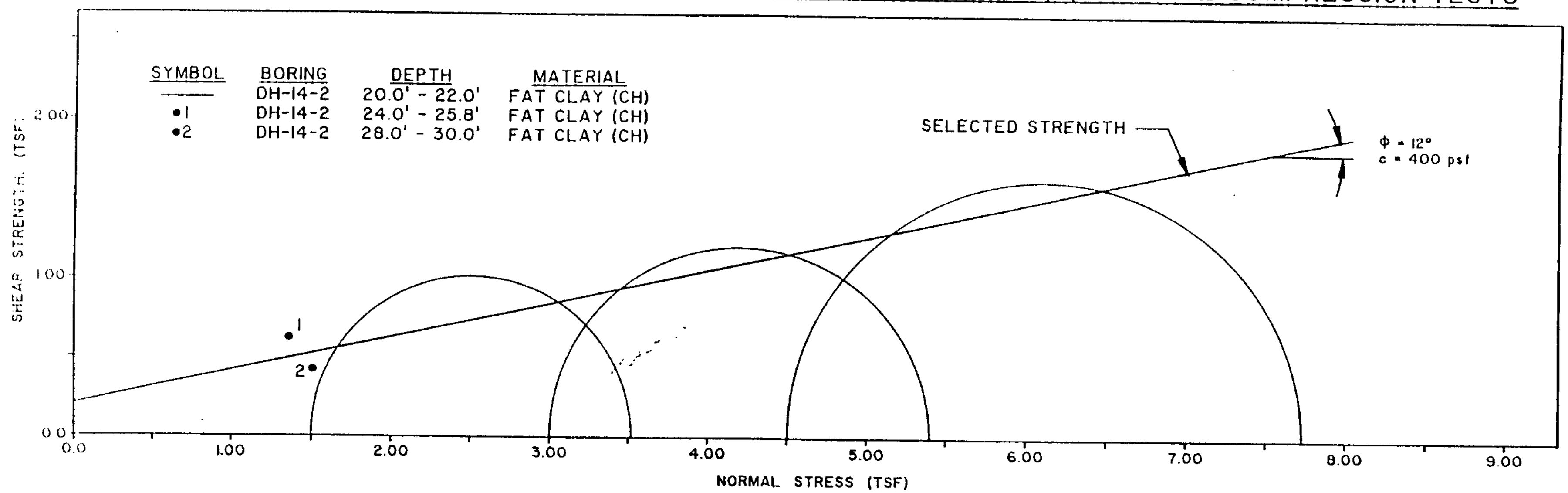
SACRAMENTO METROPOLITAN AREA
SACRAMENTO, CALIFORNIA

FEASIBILITY STUDY
LEVEE RAISE INVESTIGATION
YOLO BYPASS

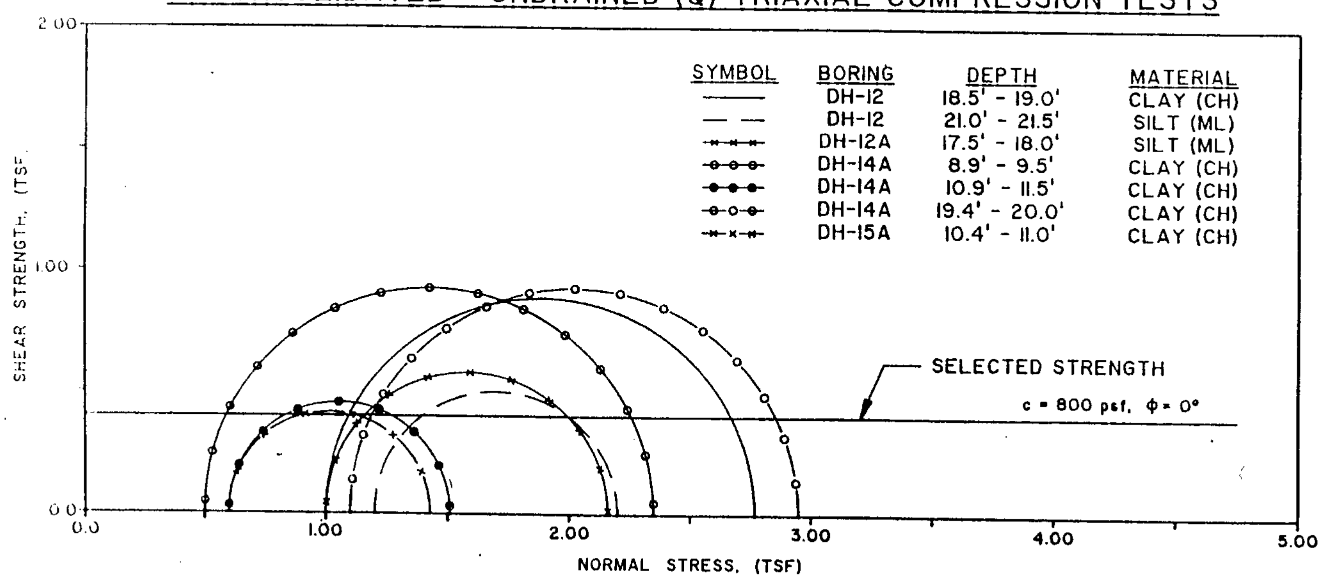
SHEAR STRENGTH SUMMARY

EXISTING LEVEE SOILS

UNCONFINED COMPRESSION (UC) AND CONSOLIDATED - UNDRAINED (R) TRIAXIAL COMPRESSION TESTS



UNCONSOLIDATED - UNDRAINED (Q) TRIAXIAL COMPRESSION TESTS



NOTE:

1. UNCONFINED COMPRESSION TEST RESULTS (1 & 2) ARE APPROXIMATELY EQUAL TO CONSOLIDATED-UNDRAINED TESTS ON THE SAME CLAY UNDER CONFINING PRESSURE σ_3, WHERE $\sigma_3 \approx 0.9\ \bar{\sigma}_v$.

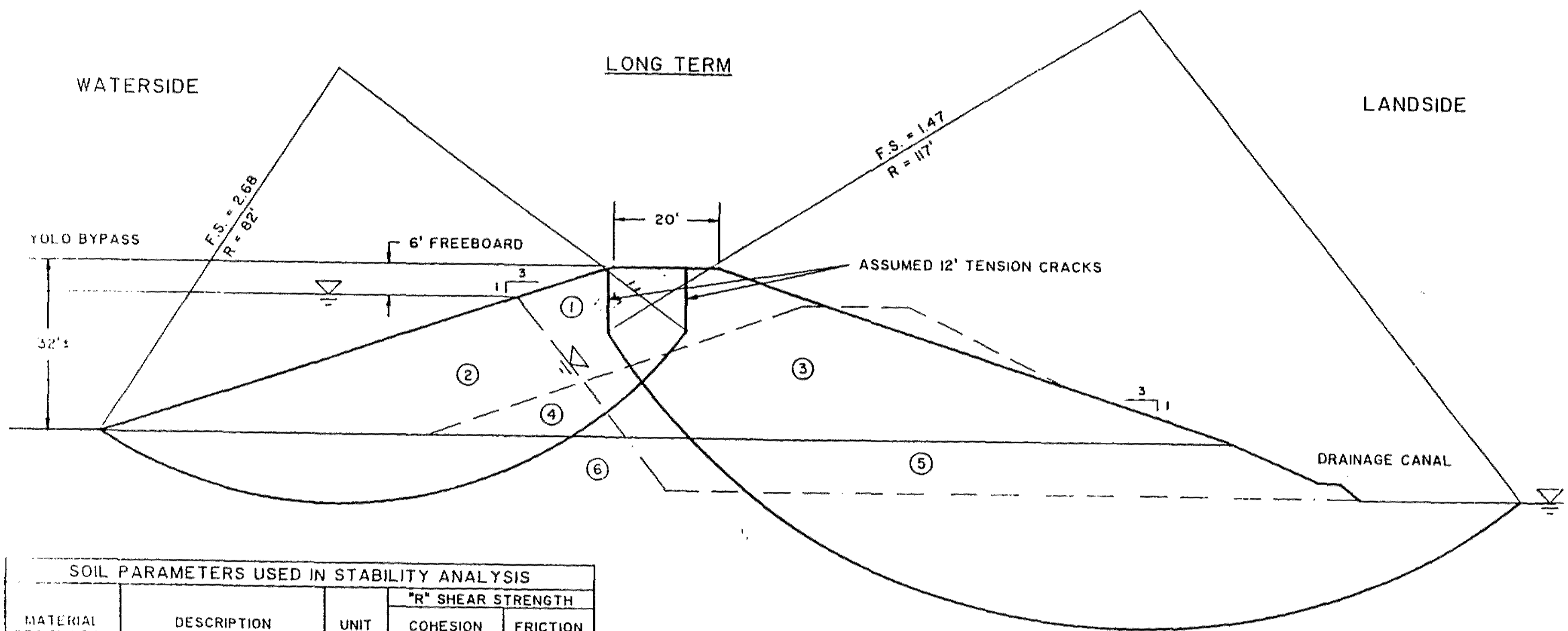
SACRAMENTO METROPOLITAN AREA
SACRAMENTO, CALIFORNIA

FEASIBILITY STUDY
LEVEE RAISE INVESTIGATION
YOLO BYPASS

SHEAR STRENGTH SUMMARY

FOUNDATION SOILS

PLATE -



TYPICAL SECTION
SCALE: 1" = 20'

SOIL PARAMETERS USED IN STABILITY ANALYSIS				
MATERIAL DESIGNATION	DESCRIPTION	UNIT WEIGHT (pcf)	"R" SHEAR STRENGTH COHESION (psf)	"R" SHEAR STRENGTH FRICTION ANGLE (degrees)
1	NEW LEVEE FILL	110	600	15°
2	SATURATED LEVEE FILL	120	600	15°
3	MOIST EXISTING LEVEE (CL-CH)	100	600	11°
4	SATURATED EXISTING LEVEE (CL-CH)	110	600	11°
5	MOIST FOUNDATION (CH)	120	400	12°
6	SATURATED FOUNDATION (CH)	120	400	12°

LEGEND

ESTIMATED PHREATIC SURFACE

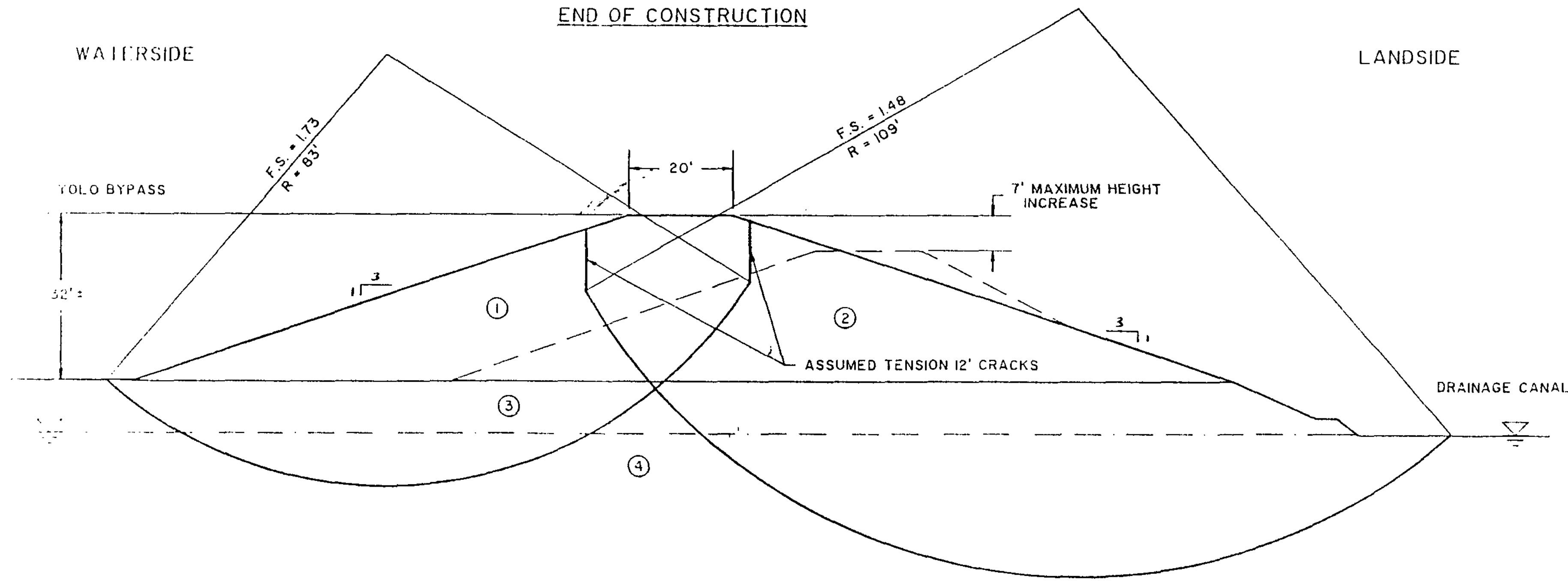
GRAPHIC SCALE

1" = 20' 0 10' 20' 40' 60'

GEOTECHNICAL BRANCH

RD - 537 (CHP ACADEMY SITE)
STABILITY ANALYSIS RESULTS

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS



MATERIAL DESIGNATION	DESCRIPTION	UNIT WEIGHT (pcf)	"Q" SHEAR STRENGTH COHESION (psf)	FRICTION ANGLE (degrees)
1	NEW LEVEE FILL	110	1500	10°
2	EXISTING LEVEE (CL-CH)	100	1000	0°
3	MOIST FOUNDATION (CH)	120	800	0°
4	SATURATED FOUNDATION (CH)	120	800	0°

SOIL PARAMETERS USED IN STABILITY ANALYSIS

TYPICAL SECTION
SCALE: 1" = 20'

LEGEND

ESTIMATED PHREATIC SURFACE

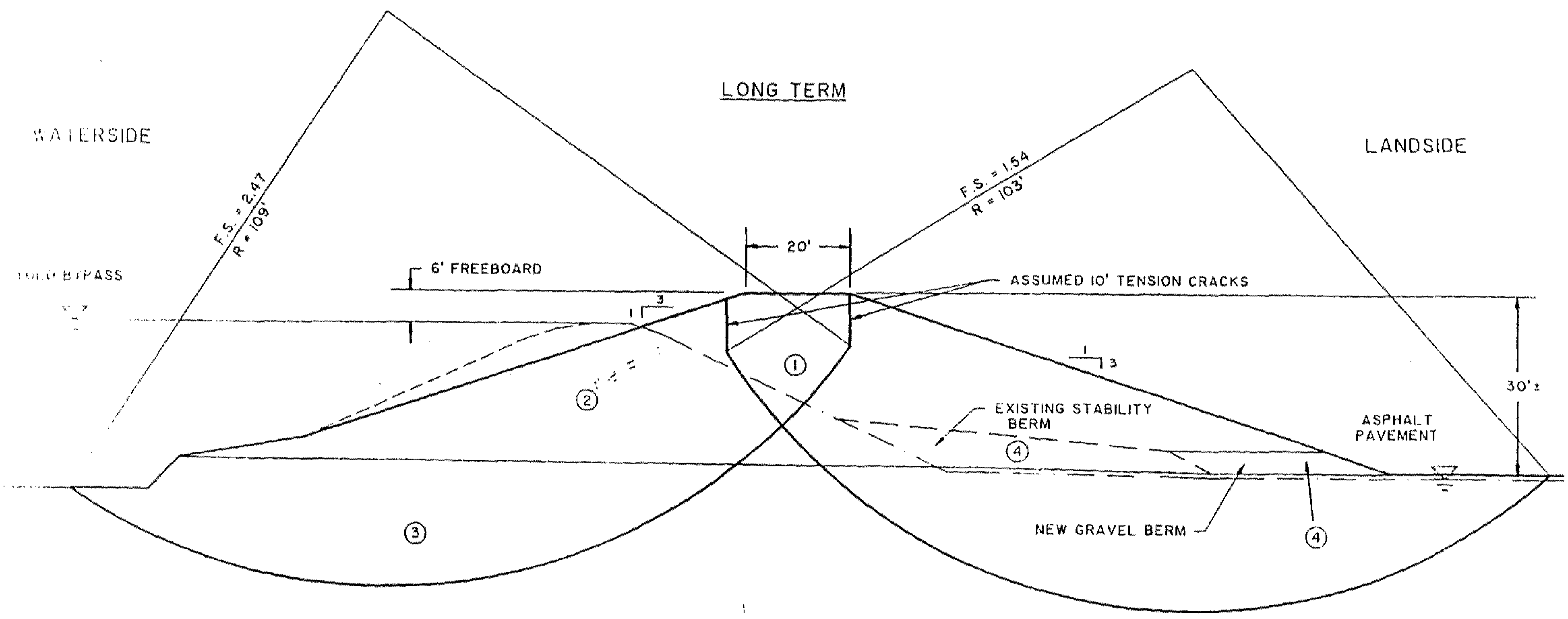
GRAPHIC SCALE
1" = 20' — 0, 10', 20', 40', 60'

GEOTECHNICAL BRANCH

RD - 537 (CHP ACADEMY SITE)
STABILITY ANALYSIS RESULTS

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS

PLATE



SOIL PARAMETERS USED IN STABILITY ANALYSIS				
MATERIAL DESIGNATION	DESCRIPTION	UNIT WEIGHT (pcf)	"R" SHEAR STRENGTH COHESION (psf)	"R" SHEAR STRENGTH FRICTION ANGLE (degrees)
1	NEW LEVEE FILL	110	600	15°
2	SATURATED EXISTING LEVEE (CL-CH)	110	600	11°
3	SATURATED FOUNDATION (CH)	120	400	12°
4	GRAVEL BERM (GP)	130	0	36°

TYPICAL SECTION

SCALE: 1" = 20'

"BERM AREA"

LEGEND

ESTIMATED PHREATIC SURFACE

GRAPHIC SCALE

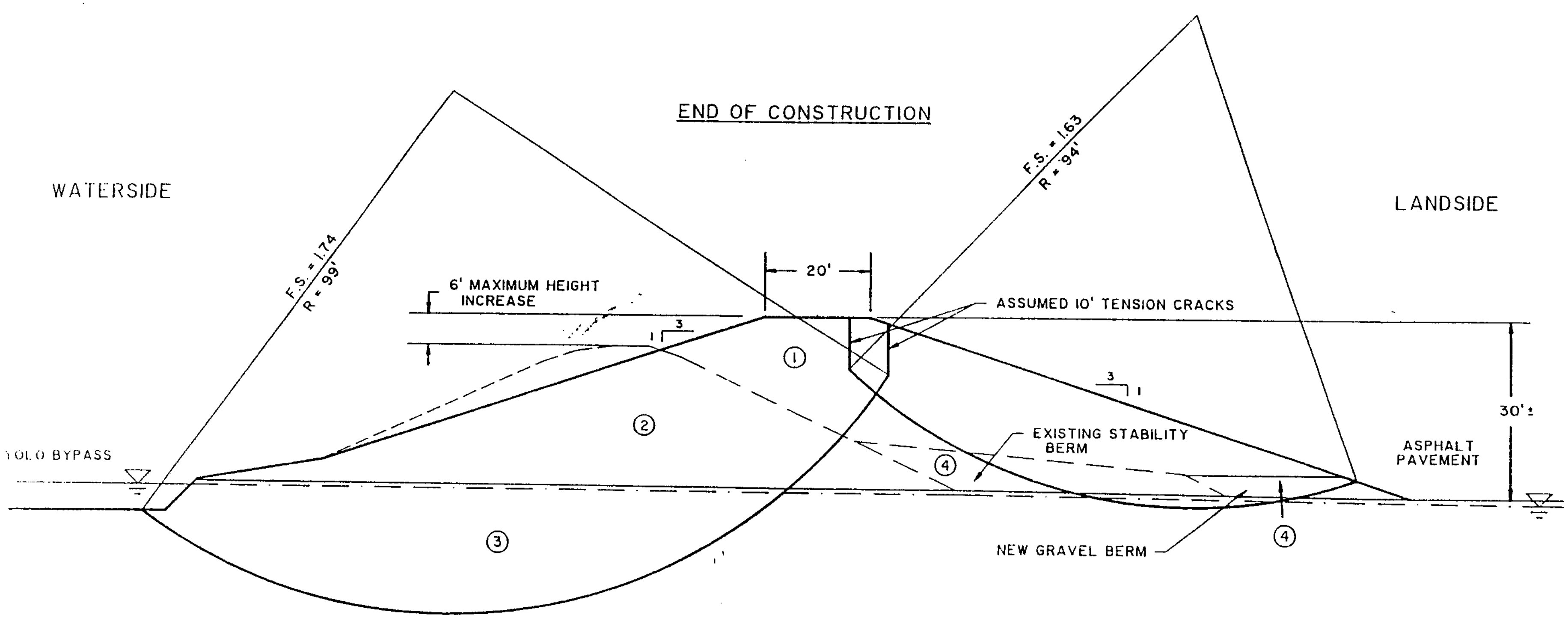
1" = 20' 0 10' 20' 40' 60'

GEOTECHNICAL BRANCH

RD - 900 (AUCTION YARD SITE)
STABILITY ANALYSIS RESULTS

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS

PLATE



MATERIAL DESIGNATION	DESCRIPTION	UNIT WEIGHT (pcf)	"Q" SHEAR STRENGTH COHESION (psf)	FRICTION ANGLE (degrees)
1	NEW LEVEE FILL	110	1500	10°
2	EXISTING LEVEE (CL-CH)	100	1000	0°
3	SATURATED FOUNDATION (CH)	120	800	0°
4	GRAVEL BERM (GP)	130	0	36°

Table title: SOIL PARAMETERS USED IN STABILITY ANALYSIS

TYPICAL SECTION
SCALE: 1" = 20'
"BERM AREA"

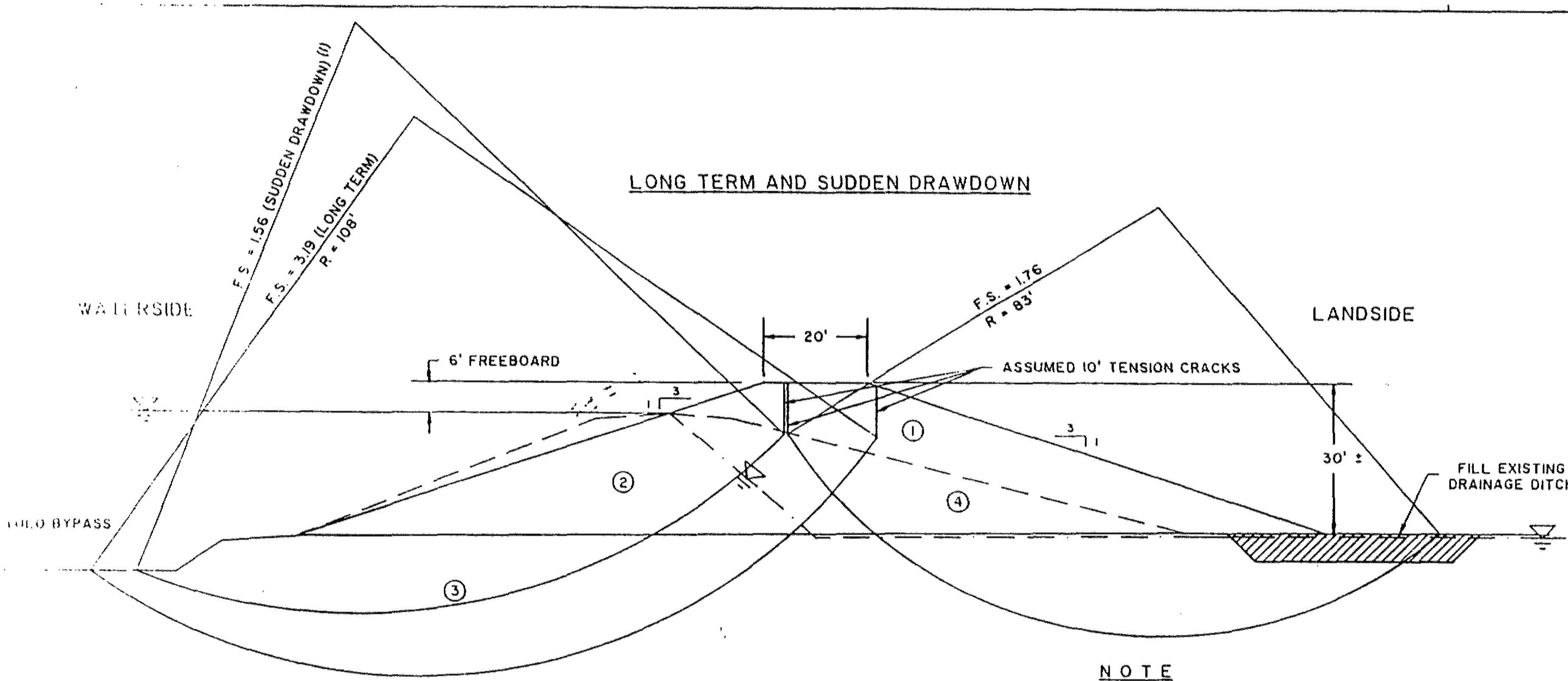
LEGEND

ESTIMATED PHREATIC SURFACE

GRAPHIC SCALE
1" = 20' 0 10' 20' 40' 60'

GEOTECHNICAL BRANCH
RD - 900 (AUCTION YARD SITE)
STABILITY ANALYSIS RESULTS
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS

PLATE 8



MATERIAL DESIGNATION	DESCRIPTION	UNIT WEIGHT (pcf)	"R" SHEAR STRENGTH COHESION (psf)	FRICTION ANGLE (degrees)
1	NEW LEVEE FILL	110	600	15°
2	SATURATED EXISTING LEVEE (CL-CH)	110	600	11°
3	SATURATED FOUNDATION (CH)	120	400	12°
4	EXISTING LEVEE (CL-CH)	100	600	11°

SOIL PARAMETERS USED IN STABILITY ANALYSIS

TYPICAL SECTION

SCALE: 1" = 20'

"DITCH AREA"

NOTE

1. SUDDEN DRAWDOWN STABILITY ANALYSIS USED THE COMPOSITE S AND R STRENGTH ENVELOPE (I.E. S WHERE S < R AND R WHERE S > R. S Ø IS ASSUMED TO BE 32°).

LEGEND

ESTIMATED PHREATIC SURFACE

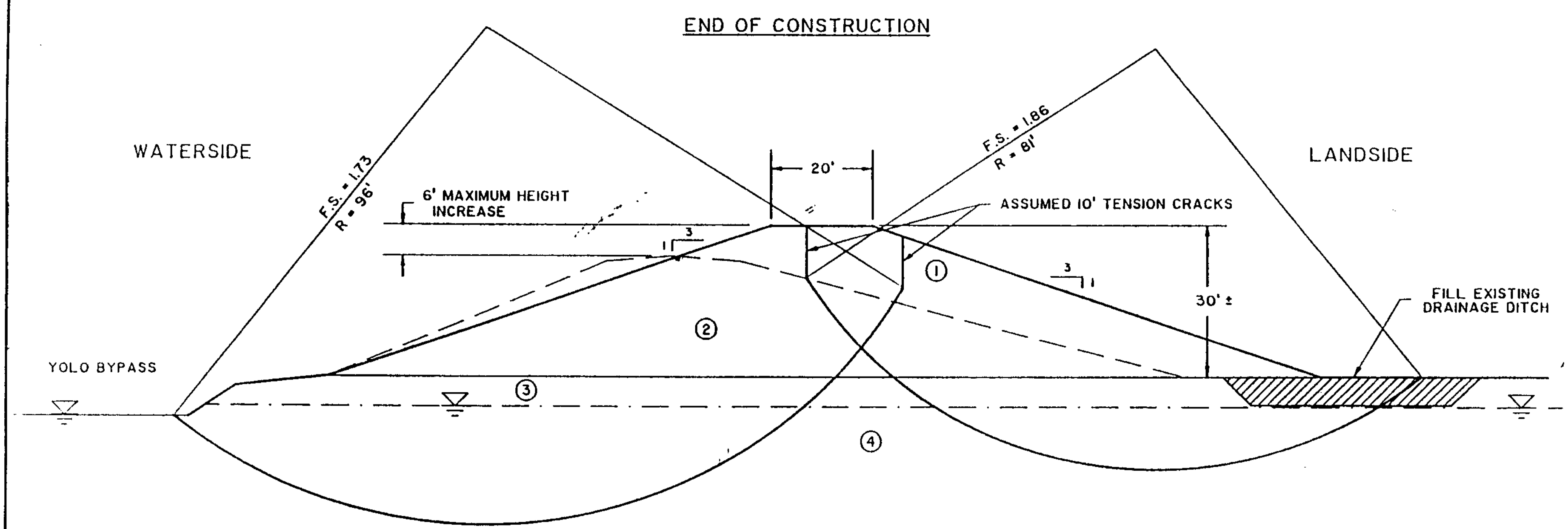
GRAPHIC SCALE

1" = 20' 0 10' 20' 40' 60'

GEOTECHNICAL BRANCH

RD - 900 (AUCTION YARD SITE)
STABILITY ANALYSIS RESULTS

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS



MATERIAL DESIGNATION	DESCRIPTION	UNIT WEIGHT (pcf)	"Q" SHEAR STRENGTH COHESION (psf)	FRICTION ANGLE (degrees)
1	NEW LEVEE FILL	110	1500	10°
2	EXISTING LEVEE (CL-CH)	100	1000	0°
3	MOIST FOUNDATION (CH)	120	800	0°
4	SATURATED FOUNDATION (CH)	120	800	0°

Table title: SOIL PARAMETERS USED IN STABILITY ANALYSIS

TYPICAL SECTION
SCALE: 1" = 20'
"DITCH AREA"

LEGEND

ESTIMATED PHREATIC SURFACE

GRAPHIC SCALE

1" = 20'   0 10' 20' 40' 60'

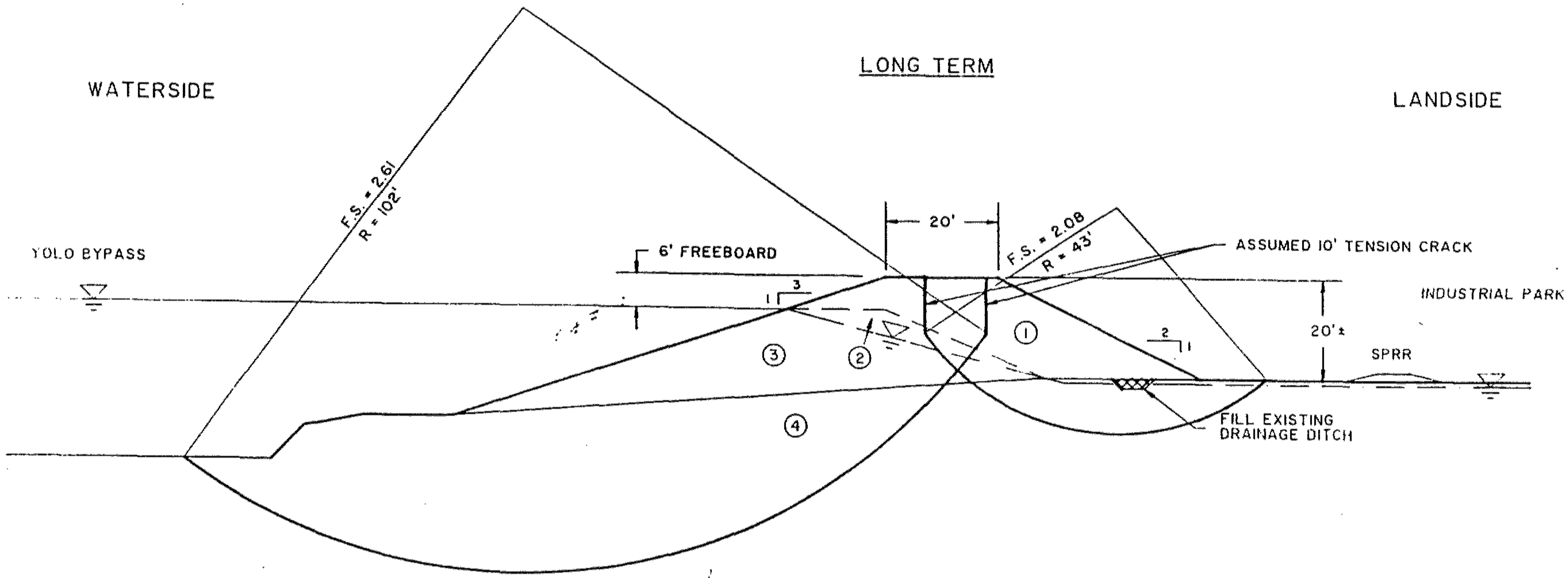
GEOTECHNICAL BRANCH

RD - 900 (AUCTION YARD SITE)
STABILITY ANALYSIS RESULTS

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS

PLATE 10

LONG TERM



SOIL PARAMETERS USED IN STABILITY ANALYSIS				
MATERIAL DESIGNATION	DESCRIPTION	UNIT WEIGHT (pcf)	"R" SHEAR STRENGTH COHESION (psf)	"R" SHEAR STRENGTH FRICTION ANGLE (degrees)
1	NEW LEVEE FILL	110	600	15°
2	EXISTING LEVEE (CL-CH)	100	600	11°
3	SATURATED EXISTING LEVEE (CL-CH)	110	600	11°
4	SATURATED FOUNDATION (CH)	120	400	12°

TYPICAL SECTION

SCALE: 1" = 20'

L E G E N D

ESTIMATED PHREATIC SURFACE

GRAPHIC SCALE

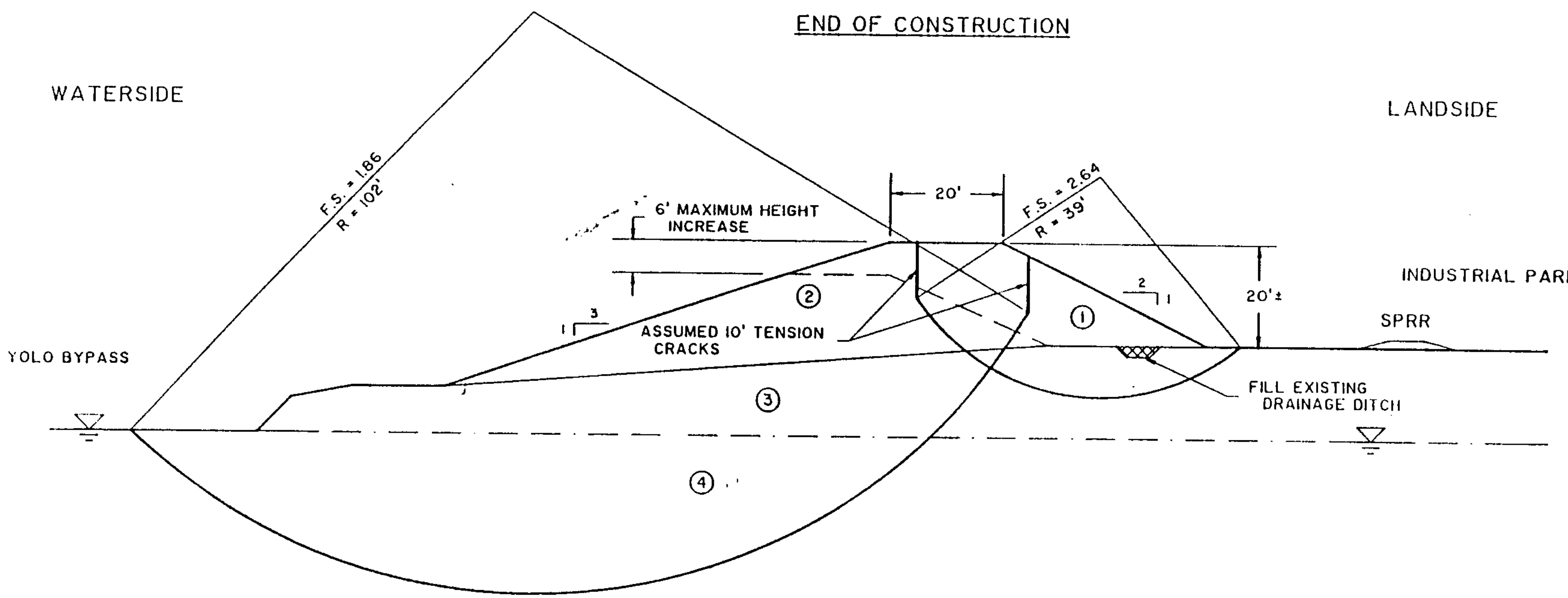
1" = 20' 0 10' 20' 40' 60'

GEOTECHNICAL BRANCH

RD - 900 (INDUSTRIAL PARK SITE)
STABILITY ANALYSIS RESULTS

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS

END OF CONSTRUCTION



SOIL PARAMETERS USED IN STABILITY ANALYSIS				
			"Q" SHEAR STRENGTH	
MATERIAL DESIGNATION	DESCRIPTION	UNIT WEIGHT (pcf)	COHESION (psf)	FRICTION ANGLE (degrees)
1	NEW LEVEE FILL	110	1500	10°
2	EXISTING LEVEE (CL-CH)	100	1000	0°
3	MOIST FOUNDATION (CH)	120	800	0°
4	SATURATED FOUNDATION (CH)	120	800	0°

TYPICAL SECTION

SCALE: 1" = 20'

LEGEND

ESTIMATED PHREATIC SURFACE

GRAPHIC SCALE

1" = 20'   0   10'   20'   40'   60'

GEOTECHNICAL BRANCH

RD - 900 (INDUSTRIAL PARK SITE)
STABILITY ANALYSIS RESULTS

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS

SACRAMENTO METROPOLITAN AREA, CALIFORNIA

FEASIBILITY REPORT

APPENDIX F

REAL ESTATE APPENDIX

SACRAMENTO METROPOLITAN AREA, CALIFORNIA

REAL ESTATE APPENDIX

1. **General description of project area.** In 1989 the Corps of Engineers (Corps), Sacramento District completed a reconnaissance study to evaluate the existing level of flood protection and increased levels of flood protection in the Sacramento Metropolitan area outside the American River Watershed Investigation. The reconnaissance study identified feasible flood control alternative for West Sacramento which included levee raising to provide 100-, 100-, or 400- year levels of protection to the city of West Sacramento.

The study area is located in Sacramento and Yolo Counties near the cities of Sacramento and West Sacramento. The study area begins just upstream of the Sacramento Weir and extends downstream to Freeport. The Sacramento Weir defines the northern boundary of the study area; the Sacramento River separates the urban areas of West Sacramento to the west and south Sacramento to the east; the west levee of the Yolo Bypass forms the western boundary; and Freeport is near the southern boundary.

The study area includes components of the Sacramento River Flood Control Project (SRFCP), including levees along the Sacramento River, Sacramento Weir, and portions of Yolo and Sacramento Bypass channels. Construction started on the SRFCP in 1918 and the various components were completed between 1952 and 1958. The SRFCP consists of a comprehensive system of levees, floodways, overbank floodway areas, enlarged and improved channels, and dredging in the lower reach of the Sacramento River. The Sacramento Deep Water Ship Channel and associated Port facilities are also located in the study area.

2. **Project real estate requirements. a. Project construction.** The selected plan consists of levee raising along the south levee of the Sacramento Bypass and continuing south along the east levee of the Yolo Bypass. Levees will be raised along 5,800 LF of the south levee of the Sacramento Bypass and 24,800 LF of the Yolo Bypass east levee. Levee raising will occur landward along the south side of the Sacramento Bypass and south of the Southern Pacific Railroad (SPRR) on the Yolo Bypass, and waterward between the Sacramento Bypass and the SPRR.

For the selected plan the non-Federal sponsor will be required to obtain approximately 18.6 acres of permanent levee easements, 10.3 acres of temporary construction easements, 70 acres of temporary borrow easements, and up to 70 acres in fee for environmental mitigation. Of the permanent land requirements for the selected plan, 8.5 acres are classified as

industrial/commercial and the remaining lands are agricultural Plate 1 of this appendix shows the location of the easements and vicinity of the proposed environmental mitigation site.

ESTATE	ACRES REQUIRED
Levee easement	18.6
Temp. construction easement	10.3
Temp. borrow easement	70
Fee	52.5*

* See text.

Since the levees which will be raised as part of the selected plan are components of existing Federal projects (Sacramento River Flood Control Project and Sacramento Deep Water Ship Channel), only the additional lands needed for the levee raising have been included in the baseline cost estimate. The existing project levees are owned in fee by the State of California Reclamation Board, Reclamation District 900, Reclamation District 537 and the Sacramento Yolo Port District.

By deeds dated in 1931 and 1933, Reclamation District 900 granted the State Reclamation Board a "perpetual easement to use, operate, reconstruct, repair, and enlarge those certain levees and other works of reclamation"...and a "perpetual easement to use, construct, operate, and repair such other work or works of reclamation or flood control as it shall elect...." Reclamation District 537 entered into a Common Use Agreement in 1966 with the State Reclamation Board "to facilitate any future improvement or repair...and to facilitate any future improvement or repair which the State Reclamation Board may wish to make."

In 1959 the Sacramento-Yolo Port District granted to the Corps "a perpetual easement and right of way for the construction, operation, and maintenance of a levee for public use, and of a patrol road or roads; and for all facilities and uses appurtenant to or necessary in connection with the foregoing...." The Corps has a maintenance agreement with the State Reclamation Board covering this levee.

Thus, the non-Federal sponsor and Corps have sufficient rights, which were obtained for prior Federal projects, to accomplish work on the existing levees. Access is already available to all construction areas by virtue of the existing projects.

The two borrow sites needed for the project include 118 acres. A 48 acre site is located within the Sacramento Bypass. The site is owned in fee by the non-Federal sponsor and is part of the SRFCP; therefore, the estimated value of this borrow site is not

included in the baseline cost estimate. A second 70 acre borrow site is on lands owned by the Sacramento-Yolo Port District. The estimated cost of a temporary borrow easement on this site is included in the baseline cost estimate. The appropriateness of the borrow sites for environmental mitigation was considered, but it was determined that one site is within the Sacramento Bypass where flows should be restricted by vegetation and the other site continues to be a spoil site for the Sacramento Deep Water Ship Channel.

Several alternate sites were considered for environmental mitigation. The site included in the baseline cost estimate is adjacent to project levees. Although 52.5 acres are needed for mitigation, 70 acres have been included in the selected plan to avoid severance damages which would occur with a smaller acquisition at the selected site. Most of the excess acreage is covered by riparian forest vegetation.

b. **Flowage easements.** Generally the non-Federal sponsor has flowage easements for occasional flooding over the privately owned land within the Sacramento and Yolo Bypasses. These easements were acquired in the 1940s and 1950s as part of the SRFCP. Since raising the levees for the selected plan will result in slightly increased flows in the bypasses, the terms and physical extent of the existing easements were reviewed. Of numerous flowage easements reviewed, none contained limitations on depth, duration or frequency of flooding.

No records have been found to document precisely the area over which the non-Federal sponsor was required to acquire flowage easements for the existing SRFCP. Existing flowage easements on the west side of the Yolo Bypass, where flows are unrestricted by levees, generally follow the design water surface elevation which corresponds to a 35- year flood event. However, within the Bypass and below the design water surface elevation, there are approximately 1,750 acres of agricultural land over which no flowage easements have ever been acquired. The non-Federal sponsor will remedy this deficiency by acquiring easements which may cost up to $1.5 million. The cost of these flowage easements is not a project cost and is not included in the baseline cost estimate.

c. **Hydraulic impacts of the project.** As previously indicated, raising the levees around West Sacramento will result in a slight increase in flows with the Yolo Bypass. The impacts of the increased flows on the west levees of the bypass and the area unrestricted by the levees south of Putah Creek was analyzed. Consideration was given to the highest and best use of the land, the current and projected levels of flood protection, and the impacts to existing depth, duration and/or frequency of flooding as a result of the selected plan. It was determined that the effects of the selected plan on the lands on the west side of the Yolo Bypass do not cause substantial interference with the present beneficial use of the land. There is no significant increase in the depth, duration or frequency of flooding over that which

already occurs such that the beneficial use of the land would be affected. Any increase in the flooding over that which already occurs without the selected plan is considered "di minimus" for purposes of considering a "taking" under the U.S. Constitution and, therefore, just compensation is not appropriate.

With respect to the potential for slightly earlier levee failure in the west levees, there is no certainty that failure will in fact occur or where it may happen. In addition, it is uncertain what type of breach would actually occur, if any, and more importantly, what result would be caused by such a breach. There exists merely a potential for an earlier failure. Considering that the property in the adjacent areas is agricultural in zoning and use, there is no indication that either the value or use of the property is affected by the relatively minor change in potential for levee failure. Since substantial interference with, or deprivation of, beneficial use of the property will not occur, there is no "taking" of the property.

3. **Estates.** The non-Federal sponsor will acquire the minimum interests in real estate which will support the construction and subsequent operation and maintenance of the project. Estates to be acquired include fee, levee easements, and temporary construction easements with the right to borrow. The estates to be acquired are the standard estates prescribed by Corps regulations, except the estate language customarily used by the non-Federal sponsor differs slightly from the language of the Corps standard estates. Prior to the start of negotiations, the Corps will review the sponsor's proposed estate language to ensure that (a) there will be no impediment to the construction, operation or maintenance of the project; and (b) that the sponsor's estate language does not enhance the minimum rights needed such that an appreciable increase in fair market value may result.

The existing flowage easements within the Yolo Bypass were reviewed for adequacy. The easements, most of which were acquired approximately 40 years ago, provide for "a perpetual right and easement, without recourse to compensation for damage therefrom, past, present or future, for the passage of all flood waters of the Yolo Bypass, which may from time to time inundate, or which has heretofore inundated, the lands of the grantors, or any portion thereof, together with the right to enter upon and clear any and all of said lands of any and all trees, brush and other obstructions...." The easement does not specifically prohibit the construction of structures for human habitation and, in fact, a few dwellings are located within the Bypass. The non-Federal sponsor will not be required to amend or renegotiate the existing easements for this project.

4. **PL 91-646 relocations.** Implementation of the selected plan will not result in any relocations under the provisions of PL 91-646. The lands required for the selected plan are adjacent to existing levees. No homes or businesses are located on the lands needed for the selected plan.

5. **Minerals.** No commercial mineral operations were noted during inspections of the project limits. No enhancement for mineral deposits is included in the cost estimate.

6. **Facility and utility relocations.** No separate real estate costs have been identified for the relocation of utility lines. The selected plan will require the relocation of sewer and telephone lines adjacent to or crossing the alignment of levees being raised and widened. No additional lands are needed for these relocations. No roads, cemeteries or facilities will be relocated by the project.

7. **Sponsor's ability to acquire.** Assuming adequate staffing, the non-Federal sponsor, the Reclamation Board of the State of California, through the Department of Water Resources (DWR), has the ability to acquire the necessary rights in real estate for the flood control project. DWR has the power of eminent domain pursuant to Water Code Sections 8590, et seq., and Code of Civil Procedures Sections 1230.010, et seq. DWR has an experienced right-of-way staff which has acquired lands for several cost shared flood control projects since implementation of the Water Resources Development Act of 1986.

8. **Acquisition schedule.** The non-Federal sponsor established the acquisition schedule which is at the end of this appendix. The sponsor of its own volition has scheduled preliminary acquisition activities before the signing of the LCA. The sponsor is aware of the risks of initiating the acquisition process before the Local Cooperation Agreement is signed.

9. **Baseline cost estimate.** The baseline cost estimate for lands, easements and rights-of-way, including non-Federal acquisition costs and Federal review costs, is $1,854,500. A gross appraisal was prepared in accordance with draft Chapter 12 of ER 405-1-2. The baseline cost estimate includes the fair market value of all lands needed for the project exclusive of lands which have been previously contributed to a Federal project. Contingency factors take into account unknown property splits, unknown condemnation settlement, undetected improvements, minor project design changes, and may vary due to availability of market data, and accessibility of the site(s).

The difference between State and Federal appraisal rules have been considered and are not expected to have any appreciable impact on the estimated real estate costs.

The non-Federal acquisition costs were estimated by the non-Federal sponsor.

11. **Hazardous or toxic waste.** During field visits staff of the Appraisal Branch of the Real Estate Division noted no obvious hazardous or toxic waste sites in the project area. More thorough reviews will be conducted but at this time there is no reason to anticipate an impact on land or acquisition costs.

10. **Maps.** The real estate requirements for the selected plan are depicted on the plate attached to this appendix.

REAL ESTATE MILESTONES				
WEST SACRAMENTO	COE START	COE FINISH	NFS START	NFS FINISH
Receipt of final drawings from Engineering/PM		10/95		
Execution of LCA	10/95			
Formal transmittal of final ROW drawings & instruction to acquire LERRD		10/95		
Conduct landowner meetings			10/95	3/96
Prepare/review mapping & legal descriptions			6/95	6/96
Obtain/review title evidence			7/95	7/96
Obtain/review tract appraisals			3/96	8/96
Conduct negotiations			4/96	9/96
Perform closings			6/96	11/96
Prepare/review condemnations			9/96	12/96
Perform condemnations			12/96	3/97
Obtain possession			1/97	4/97
Complete/review PL 91-646 benefit assistance		N/A	N/A	
Conduct/review facility and utility relocations			3/96	11/96
Certify all necessary LERRD is available for construction	4/97	7/97		4/97
Prepare and submit credit requests			4/97	6/97
Review/approve or deny credit requests	7/97	8/97		
Establish value for creditable LERRD in F&A cost accounting system	8/97	8/97		

SACRAMENTO METROPOLITAN AREA, CALIFORNIA

FEASIBILITY REPORT

APPENDIX G

FINANCIAL PLAN

DRAFT NO. 1
January 16, 1992

SACRAMENTO METROPOLITAN AREA FEASIBILITY REPORT

Financing Plan for the Construction of the Authorized Alternative

The Reclamation Board
January 1992

The recommended plan in the Sacramento Metropolitan Area Feasibility Report is intended to be submitted as a federally authorized flood control project on a tributary of the Sacramento River. Section 12657 of the California Water Code provides authority for the State to pay for lands, easements, rights of way, and relocations on federally authorized flood control projects in the Sacramento and San Joaquin Valleys.

The State, in cooperation with other nonfederal agencies, intends to pay all of the nonfederal capital costs for this project as required by Public Law 99-662, including the 5 percent cash requirement, lands, easements, rights of way, relocations, and assures that the project will be maintained to federal standards. Section 12585.5 of the California Water Code provides for the State to pay 70 percent of the nonfederal capital costs as required by PL 99-662, as well as the nonfederal costs of fish and wildlife mitigation, and the nonfederal costs of planning, engineering, and design. Reclamation District 900 and the City of West Sacramento who participated in the cost sharing for the feasibility report have indicated their willingness to act as cost-sharing partners with the State for the proposed project.

Other reclamation districts within the City of West Sacramento may also decide to participate in the project.

Pursuant to its role as the local sponsor of the selected alternative, The Reclamation Board will be responsible for the operation, maintenance, repair, replacement, and rehabilitation of the proposed project. The Board, in turn, passes on the operation, maintenance, repair, replacement, and rehabilitation costs to the local beneficiaries of the project. Maintenance activities and funds are authorized and provided for by the local agencies. These agencies currently obtain their funds through existing benefit assessment districts.

The levees designated for raising are currently maintained by Reclamation Districts 900 and 537 and the State Department of Water Resources. After construction of the project, these entities will maintain the improved levees.

Nothing herein shall constitute, or be deemed to constitute, an obligation of future appropriations made by the Legislature of the State of California.

Raymond E. Barsch
General Manager

SACRAMENTO METROPOLITAN AREA, CALIFORNIA

FEASIBILITY REPORT

APPENDIX H

TRANSCIPT OF PUBLIC HEARING

ORIGINAL

Public Hearing
U. S. ARMY CORPS OF ENGINEERS
and
THE RECLAMATION BOARD, STATE OF CALIFORNIA

---o0o----

Subject: Sacramento Metropolitan Area, Feasibility Study, and EIS/EIR

---o0o----

Tuesday, December 10, 1991
7:00 P.M.

---o0o---

ALICE BOOK
CERTIFIED SHORTHAND REPORTER
14112 MARBLE QUARRY ROAD
COLUMBIA CA 95310
PHONES. 916 457-7326 & 209 532-2318

Hearing Panel

RAY BARSCH, General Manager, Reclamation Board

LT. COL. TIMOTHY MASON, Deputy District Engineer, Corps of Engineers

---o0o---

A G E N D A

---o0o---

TUESDAY, DECEMBER 10, 1991, 7:00 P.M.

---oOo---

MR. BARSCH: We were waiting just a little longer in case somebody was out in the parking lot.

Has everyone that's here that is not a member of the staff signed a card that wants to sign a card, either for the mailing list or to speak this evening?

Okay, I don't see anyone rushing to the back of the room. I guess we are okay.

I am Ray Barsch, General Manager of the State Reclamation Board.

I would like to welcome you here this evening and we are getting ready to have a public hearing on the Sacramento Metropolitan Area, Draft Feasibility Report, Environmental Impact Statement and Environmental Impact Report, and if you don't have your copy yet or haven't had a chance to read it, I think we can fix you up. We do have some in the back so you don't have to wait for us to mail it.

I think we met here in this same room two years ago -- well, it is two years ago, and, in fact, it was December 2, so it is a little over two years ago.

Dick Fazio was here and the Mayor of West Sacramento and we got this thing kicked off with the effort of a lot of people here this evening and others that have

been represented at some of the workshops.

The report is out and certainly once we have the comments, why we will be moving along toward the final report.

The major effort was done, of course, by the Corps of Engineers with the help of Reclamation Board, as well as the financial effort from several others, and just so I won't miss anyone that did work on that or contributed to it, I would like to list those:

There's five Reclamation Districts, 537, 811, 900 1600 and 2668, and some of those are represented here tonight; and then Yolo County contributed and Yolo County Flood Control and Water Conservation District, and of course, then, the City of West Sacramento and the State and the Corps, so that's the cost-sharing partners in this study.

Tonight we at least planned to take testimony. I'm not sure we're going to get any comments yet, but we will see here in a minute, but this planning effort, as I mentioned, started a couple of years ago and has been moving forward. Certainly, after the 1986 event, it was obvious that we did not have flood protection in this area, at least as much as was needed, and this study now says that there's a feasible solution to the problem, and that we can go from approximately the seventy-year

protection that exists as of the moment to as high as four hundred years, depending on how high we raise the levees.

So, with that introduction, I would like to introduce one gentleman back there that's with us tonight, Richard Harris, representing Congressman Fazio's office, and then I would like to mention a few of our staff members that are here tonight.

Our Board President, Wally McCormack, who was here before and who has been at several of the meetings, was not able to attend tonight, but our Chief Engineer, Rod Mayer is up here and Board Counsel, Ward Tabor, is the gentleman sitting here to my right.

Two of the engineers that have worked on the report that will be working as we go on through towards the final report are Ricardo Pineda and Victor Pacheco, and there are some others certainly that are here, so with that, I guess I would like to ask then Lieutenant Colonel Mason, who is Deputy District Engineer of the Corps of Engineers, to say a few words and then introduce the rest of the program.

Colonel Mason.

COLONEL MASON: Thanks, Ray.

Welcome. This is an important step in the process which we have been following for quite a while now.

As Ray said, we would take public comment tonight as part of the official record. Those comments will be

incorporated into the final record which will then wind its way up the line towards authorization.

Before we talk about the project specifically, I would like to introduce some of the Corps people here, introduce the Corps people to the other half of the audience.

We have Walter Yep, Chief of our Planning Division; and from Planning Division, also, Susan Ramos, Allan Otto; Ray Williams from our Engineering Division, Bob Childs from Project Management; and in the back, Jim Taylor, Homer Perkins from our Public Affairs Office.

I think that's all, and that takes care of about seventy-five percent of the audience.

So at this point, what I would like to do is introduce Susan Ramos as the Study Manager who will give a short briefing on the project itself and a report.

MS. RAMOS: Good evening. I think I should apologize first for those of you who have heard this speech before. It is going to be a rerun.

Tonight I would like to just briefly go over the information that's contained in our Draft Feasibility Report and accompanying environmental documents. That report was released on November 8 for public review and it is currently undergoing public review and the comment period will end on December 13.

What I would like to talk about tonight specifically is to discuss the study area, the threat of flooding to the area, how we formulated the plans that are outlined in the Draft Report, and then, finally, to describe the actual proposed project and our future schedule of where we are going to go from here.

The study area shown here on this slide includes both that area highlighted in yellow and the reddish orange area.

Initially the study area dealt with property from Fremont Weir south to just south of Freeport and included three main developed areas; Elkhorn area, West Sacramento area, and the South Sacramento area.

Our initial studies looked at basically five alternatives for providing flood control protection to those developed areas. Two of them dealt with modifying both the Sacramento and Fremont Weirs and the idea here was we would lengthen the weir and lower the weir crest to provide for area of flows through the bypass, thereby lowering the stages in the Sacramento River.

The other thing we looked at was the idea of diverting water from the bypass in the Sacramento River to the Ship Channel, again lowering stages in the Sacramento River, and also, the idea of raising levees around the developed area.

This shows West Sacramento, but we would be looking at Elkhorn, and South Sacramento also in the initial studies.

And finally, removing constrictions in the bypass, i.e., widening the area between piers on I-80, and also, the possibility of removing fill along the railroad tracks and replacing that with piers.

As you can see from this slide, there were several feasible alternatives; one being the idea of modifying the Fremont Weir. However, what our studies indicated is that the primary beneficiaries of this alternative was the area of Natomas, and since Natomas was being studied in the American River investigation, this alternative was transferred to that study for further analysis.

In the case of the Sacramento Weir, our studies indicated that the primary cause of flooding in the West Sacramento area was from the Yolo Bypass as opposed to the Sacramento River. Therefore, this was really not a feasible alternative.

So the alternative which was continued for additional study was the idea of raising levees around these developed areas.

The idea of raising these levees was to provide, as I mentioned earlier, protection to the Elkhorn area. What our studies indicated was that raising levees in the

Elkhorn area provided protection to that area. However, the primary land use is agricultural, and the cost of raising those levees far exceeded the benefits derived from such levee raising for flood protection. Therefore, this area was determined to have been separated from the study and is being analyzed under the Yolo recon study right now and they are looking at providing protection for that area with the possibility of including in their analysis future development.

In the South Sacramento area it was determined that by implementing the Auburn Dam the existing levees in that area were sufficient as they exist to provide protection to the South Sacramento area. That area is being analyzed also under the American River investigation.

So, basically, what that left us with was the modified study area, that being shown here in orange, and that area includes the area from the Sacramento Bypass to just south of Freeport. So, basically, it's the city of West Sacramento.

That is how we came up with that modified study area.

I am showing this slide to give you an indication of what the floodwaters looked like during 1986, which was our flood of record.

This is a shot of the I Street Bridge and you can

just see in this example how high those floodwaters really were. Basically, on the Sacramento River the water was about a foot and a half from overtopping the tops of those levees, and in the Yolo Bypass about two feet, so this gives you an indication of the type of flood threat that exists to the City of west Sacramento.

This, again, we are looking at the Yolo Bypass towards the Port area, and you can see that water level.

This is a slide of the area showing the Union Pacific Railroad crossing, so it would be north of I-5 up in the Elkhorn area, and again, that's just to give you an indication of how high those water levels were during '86.

This slide shows that the study area, basically west Sacramento, is within the hundred-year floodplain, FEMA floodplain, so all of this area is threatened by floods. This area includes approximately 12,000 acres of land and about 30,000 people.

Total damages in this floodplain are estimated to be about 1.2 billion dollars, so there's a lot of property that could be damaged, approximately 12,000 structures of homes.

Because the area is in this floodplain, or FEMA floodplain, it comes under FEMA restrictions, the result of that being relatively high flood insurance for existing dwellings in the area if flood protection is not provided.

and the possibility of a moratorium, building moratorium being placed on the area if flood protection is not provided.

So those are the two things that we are looking at in terms of restrictions from FEMA.

Now Congressman Fazio was able to, through congressional action, delay implementation of these FEMA rates and restrictions until November of '92, which allows the community time to indicate to FEMA that it is making substantial progress towards coming up with some type of flood protection for the area.

What our Feasibility Report looked at were basically providing various levels of flood protection to the City of West Sacramento, those alternatives being the one-hundred year, the two-hundred year, the four-hundred year and greater than four hundred.

In addition, we looked at the no-action alternatve to give us a base-line case.

All of these alternatives basically involve the same structure, raising existing levees, the south levee of the Sacramento Bypass and the east levee of the Yolo Bypass.

And what we would be doing is raising those various heights to provide the various levels of protection.

This slide gives you an indication of what we are

talking about in those different heights and as you can see, they are all relatively similar. On a one-hundred-year flood protection, for instance, the maximum height raise would be about 4.7 feet, and to the four-hundred-year level of protection we would be raising the levees a maximum of 5-1/2 feet, so you can see that the difference in the various alternatives primarily centered around the difference of heights of the levees to be raised.

This slide indicates the cost associated with each of those alternatives. Basically, what I want to show here in this slide is that, as you can see, the alternative which gave us the greatest benefit for the cost expended is the four-hundred-year alternative with a BC ratio of about 5.2 to 1, so that became the plan that maximized the net benefits and, in fact, in our Feasibility Report this is our tentatively selected plan, the four-hundred-year alternative.

This slide indicates the features of the four-hundred-year alternative. Basically what these include are raising about a mile of the south levee on the Sacramento Bypass, and that's on a height of 5 feet and raising the east levee on the Yolo Bypass about 4.7 miles in length to a maximum height of 5-1/2 feet, and the average raise would be between 3 to 4 feet; and in addition

to raising these levees, we would also be installing a floodgate and placing some riprap on those levees when we raise the additional height.

Basically, what I am showing here is the location of the tentatively selected plan which I just described.

Now, in order to complete these levee raisings, obviously we will need borrow or fill material. This slide shows the two possible sites for that fill material, the borrow material.

Site one is in the Sacramento Bypass and that area would provide about 350,000 cubic yards of borrow.

The second site, which is owned by the Sacramento Port and located in the Yolo Bypass area, would contain about 560,000 cubic yards, so we are going to need a total of about 910,000 cubic yards for these levee raisings that we are proposing.

When we propose to construct this project there are obviously some impacts with raising the levees because we would be affecting the existing vegetation on the levees. What the report has indicated is that there will be a permanent loss of about 12 acres, 11.9 shown here, of wetlands, wetlands being vegetation which is, you know, for a majority of the time inundated by water.

In addition, we would be affecting about 29 acres of uplands, uplands being dry grasses, oak wood land, that

type of vegetation.

So, we would be impacting 41 acres of vegetation and that's primarily our impact in the report. It is vegetation for wildlife.

To mitigate for this we would be acquiring approximately 52-1/2 acres of mitigation acreage. In addition, we would be causing temporary impacts to about 150 acres of land along the existing levees and we would mitigate for that by reseeding these areas.

This slide here indicates the proposed mitigation, and this information can be found in the Executive Summary. I think it is available in the back of the room, and also, in the report because I know it is kind of difficult to see on these TV monitors.

We looked at several different mitigation areas. The main problem with a lot of these was the size of the sites that were available because we are going to need at least 52 acres of mitigation. The site that is tentatively selected in the document is Site D, which is located in the Yolo Bypass, so that's the one that we are looking at now.

However, it is important to note that this is selected in the document primarily for cost purposes and for analysis. However, they are based on comments received or other information that may come in. It's always a possibility this site could be changed to one of the other

areas.

We are in the process right now of also looking at a site which is actually a Yolo County regional park site and that area is shown here. It is highlighted in yellow. I think that's also on your handout.

We are meeting with the Fish and Wildlife Service and we are going to assess the possibility of looking to mitigation there because that is sighted for development of a wetland. And so we are analyzing that in addition to the sites shown.

This slide gives an indication of the project cost. The total cost of this project is estimated to be about 17.4 million dollars. Now that obviously will be cost shared by the Federal Government, the State Government and local government. And this gives you a breakdown of that cost sharing. Basically, about 13.1 million dollars will be Federal costs with a total non-Federal cost of 4.3 million dollars, and that would be broken down again between the State for a little over 3 million dollars, and the local about 1.7 million dollars.

This final slide shows our future schedule. As I mentioned at the beginning, the comment period will end December 23. We will take the comments received and address those comments and finalize the report in accordance with those comments.

We are hoping to finalize this report in January of 1992, so in the next month, and we are anticipating congressional authorization in 1992 with the initiation of construction in 1994. The initiation would start with the acquisition of lands, et cetera.

So that concludes my very brief overview of the project and, again, as I mentioned previously, this is all described in the executive summary of the report which is available in the back, in the handout you have, in detail.

Now, we will have anyone who would like to provide us with testimony tonight.

COLONEL MASON: Okay, thank you, Susan.

With the size of the crowd here and the number of responses here we have on cards, we will have a chance for clarification questions if anyone had a question on the presentation that was just given.

Seeing none, I have five or six cards here, but none of them have a checkmark that says they want to speak.

Also, before I go on, I did want to mention if someone here has a question as far as the mitigation or any of the EIS work that was done, Annalena Bronson in the back there, she also works for the Department of Water Resources and she could probably answer any of those questions you might have, and certainly, if we don't have any comments that are given for the record, if people have

questions, we would like to have them ask those questions of staff after the meeting is adjourned because maybe we can clarify those types of questions in the final report.

I notice Fran Borcalli came in after we started.

Did you want to have anything for the record as far as -- are you representing Yolo County tonight?

MR. BORCALLI: The County is preparing a written statement, Ray, which will be transmitted before the 23rd.

MR. BARSCH: Very good. Okay.

Of course, we will take comments -- written comments will certainly be accepted until the 23rd, so if anyone knows of someone that was unable to come, pass that word on to them because we do want to get their comments.

So am I reading the cards correctly, no one is here this evening that wants to make a statement for the record at this time?

All right. Let's see if we have any other business.

Do you have anything else?

Like I said, certainly the staff has got the audience outnumbered here, but if anyone does have questions, anytning that they might want to clarify in order to make their comments in writing before the 23rd, certainly some of the staff are here tonight.

Fran, did you want to make a statement?

MR. BORCALLI: If there is no other discussion, all I would like to mention is that from the Yolo County standpoint, what will be transmitted will be consideration that I think enters into the congressional authorization, and the concern on the hydraulic mitigation is because the systems analysis for the west side is not completed, Phase 4.

The Yolo Bypass investigation is not complete so there really isn't a basis for making a determination as to whether there will be any restoration or enhancement at Willow Slough Bypass and the west levees of the Yolo Bypass at this point in time.

Now this project is going to move ahead for congressional authorization next year and once that project is authorized, the opportunity to come back retroactively is gone.

And the Corps has determined that the impacts are not significant at this point in time, and I don't think anybody is quarreling with that, except for maybe clarification on the landfill and the City of Davis waste treatment plant, but if in the future, after these other studies are done, the local entities want to restore, or let's say, provide a hundred-year level of protection in the future, the hydraulic impact from the Sacramento project will increase the cost by some increment, and there

is no way to identify what that increment would be at this point in time, but theoretically, the cost to provide a one-hundred-year level of protection in those areas in the future will be somewhat higher than if you are trying to provide it today because of the Sacramento project, based on the analysis that has been done to date.

The question is, how can that option be preserved, and as we would see it, the only way to preserve that is through the congressional authorization. You know, if, in the future there is no restoration or enhancement, then there is no question but, like I say, at this point in time, you can't make that determination because these projects are out of phase.

Not that that's a problem, except we can't make decisions in those. That's really what will be transmitted by the county asking for that type of consideration to leave the option open.

MR. BARSCH: I might just ask you a question, Fran. In the county proposal or the comments that are being sent in, would there be possibly draft language that you would like to see appear?

MR. BORCALLI: I don't know that we would be capable of drafting that, but we certainly would ask Mr. Harris through Congressman Fazio's office to assist in that regard. We would like some acknowledgment as to whether

that consideration is reasonable from the Corps and the Reclamation Board's standpoint for West Sacramento.

Like I say, the impacts today are not significant, but again, if there is going to be restoration and/or enhancement, there will be an incremental cost that can't be assigned at this point in time.

MR. BARSCH: We will certainly look at that comment when we receive it. Thank you.

I saw another hand here.

MR. SANCHEZ: I am Sevino Sanchez, a reporter from the News Ledger, and I would like to know if there is anybody here from the city.

MR. BARSCH: The City of West Sacramento?

MR. SANCHEZ: Yes.

MR. BARSCH: Mr. Clark raised his hand.

Okay, any other questions, comments or anything for the good of the cause?

The meeting is adjourned.

(The meeting was adjourned.)

REPORTER'S CERTIFICATE

---o0o---

THIS IS TO CERTIFY that I, ALICE BOOK, a Certified Shorthand Reporter, was present during the public hearing of the U. S. ARMY CORPS OF ENGINEERS and THE RECLAMATION BOARD, STATE OF CALIFORNIA, held in West Sacramento, California, on December 10, 1991; that as such I recorded in stenographic writing the proceedings therein held in the matter of Sacramento Metropolitan Area, Feasibility Study, and EIS/EIR; that I thereafter caused my stenographic writing to be transcribed into longhand typewriting and that the preceding pages 1 through 18, constitute said transcript; that the same is a true and correct transcription of my said stenographic writing for the date and subject matter hereinabove described.

Dated: December 16, 1991

Alice Book

ALICE BOOK

SACRAMENTO METROPOLITAN AREA, CALIFORNIA

FEASIBILITY REPORT

APPENDIX I

COMMENTS AND RESPONSES

APPENDIX I

COMMENTS AND RESPONSES

SACRAMENTO METROPOLITAN AREA, CALIFORNIA

U.S. ARMY COPRS OF ENGINEERS

SACRAMENTO DISTRICT

FEBRUARY 1992

SACRAMENTO METROPOLITAN AREA, STUDY

Response to Comments

TABLE OF CONTENTS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

2 0 DEC 1991

Colonel Laurence R. Sadoff
District Engineer
ATTN: CESPK-PD-B
U.S. Army Corps of Engineers
Sacramento District
1325 J Street
Sacramento, California 95814-2922

Dear Colonel Sadoff:

The Environmental Protection Agency (EPA) has reviewed the Draft Environmental Impact Statement for the project entitled **Feasibility Report and Draft Environmental Impact Statement and Environmental Impact Report Sacramento Metropolitan Area, California.** Our review is provided pursuant to the National Environmental Policy Act (NEPA), Council on Environmental Quality (CEQ) regulations (40 CFR Parts 1500-1508) and Section 309 of the Clean Air Act.

In response to flood risks in the City of West Sacramento the Corps of Engineers (COE) proposes to raise 1 mile of the south levee of the Sacramento Bypass by 5.0 feet and 4.7 miles of the Yolo Bypass east levee by 5.5 feet. Levee raising would be landward for levees of the south side of the Sacramento Bypass and the Yolo Bypass south of the Southern Pacific Railroad to the Sacramento Ship Channel. Levee raising would be on both the landward and waterward sides of the Yolo Bypass east levee between the Sacramento Bypass and Southern Pacific Railroad. Four hundred-year (400-year) level of flood protection would be provided to the City of West Sacramento.

The with- and without-project conditions assume implementation of the Locally Preferred Plan (200-year level of protection alternative) for the American River Watershed Investigation project (Feasibility Report (FR) pg. 46). Although detailed hydrologic analysis indicates the West Sacramento flood hazard is associated with higher flows in the Yolo Bypass versus in the Sacramento and American Rivers (FR pg. 52), the study areas for the two projects are not hydraulically separable (FR pg. 76). Proposed work for the American River Watershed

Investigation project would impact the amount of work needed in the Sacramento Metropolitan area to provide the desired level of flood protection. Without the proposed American River project, the Metropolitan Area tentatively selected plan would provide in excess of 150-year level of protection (versus 400-year level of protection) to the City of West Sacramento (FR pg. 77). The COE proposes to combine the American River Watershed Investigation and Sacramento Metropolitan Area projects into a single, comprehensive plan during the design and construction phase (FR pg. 46).

Other related projects in the Sacramento area include: Sacramento River Flood Control System Evaluation (levee repair); Folsom Dam and Reservoir Reoperation; Westside Yolo Bypass Levee Reconnaissance Study; Cache Creek Settling Basin Project; Yolo Basin Wetlands Project; Bureau of Reclamation's multipurpose Auburn Dam; and Bureau of Land Management American River National Recreation Area Study.

EPA recognizes the critical need for long-term flood protection in the Sacramento area. We support the protection of existing property and structures from flood damage and believe that protection method(s) should be selected which will, with mitigation for unavoidable impacts, also minimize damage to the natural environment.

We commend the COE for their substantial efforts to reconcile the needs of conflicting interest groups and to provide solutions to the serious, complex problem of flood control for the Sacramento area. We recognize the tremendous efforts of your staff to produce adequate and timely environmental documents for the numerous flood control projects in this area. Nevertheless,
1. we are concerned with the planning sequence and NEPA process used by the COE. It appears that evaluation and approval of major projects (e.g., American River project, DEIS 2/91) which rely on adequate levee repair (Sacramento Systems Evaluation, DEIS 12/91) and levee improvements (Sacramento Metropolitan, DEIS 11/91) is occurring prior to evaluation and approval of these supporting projects. To ensure consistent decisions, evaluation and approval of projects which provide necessary components for future actions should be accomplished prior to or in close parallel with approval of these future actions.

2. In addition, we are concerned with the appropriateness of assuming implementation of the Locally Preferred Plan for the American River Watershed Investigation project prior to approval of this project. Given the hydrological connection and future fusing of the two projects at the design stage, we believe it may have been more appropriate to have considered the Sacramento Metropolitan project as a component of the American River Watershed Investigation project. Our concerns with this planning sequence and NEPA process have been conveyed to the COE over the last two years via Feasibility Review Conferences, scoping meetings, and correspondence.

We believe the DEIS has insufficient information to demonstrate compliance with NEPA because:

3. * It does not "rigorously explore and objectively evaluate all alternatives (40 CFR section 1502.14(a))." For instance, the DEIS provides only a description of non-levee alternatives and a minimal analysis for their elimination from further consideration. We remain concerned that National Economic Development (NED) Guidelines have driven the alternatives analysis process in a manner which limited full consideration of some potentially less environmentally damaging alternatives.

4. * It does not sufficiently discuss compliance with environmental statutes, including the Clean Water Act and the Clean Air Act (40 CFR sections 1502.16, 1506.2(d) and 1508.8). For instance, the DEIS does not demonstrate compliance with the 404(b)(1) Guidelines nor air quality conformity pursuant to the Clean Air Act.

5. * It does not sufficiently discuss the means to mitigate adverse direct, indirect, and cumulative impacts (40 CFR 1508.20). While the DEIS outlines possible mitigation for direct impacts, there is limited information on mitigation for indirect and cumulative impacts and minimal discussion of the probability of mitigation implementation.

6. EPA is also concerned with the disparities between the U.S Fish and Wildlife Service and Corps of Engineers environmental impact analyses and the implications for proposed mitigation measures. We believe it is critical that there be agreement on the extent of impacts in order for decision makers and the public to make decisions based on an understanding of environmental consequences, and to take actions that protect, restore, and enhance the environment.

7. The COE has stated their intention to seek a 404(r) Clean Water Act exemption from Congress. To comply with 404(r) exemption requirements, the COE must fully consider the 404(b)(1) Guidelines in this EIS. EPA is obligated to comment on whether the proposal is in compliance with these Guidelines. Because of the insufficient information in the DEIS, EPA is unable to make a positive determination of compliance. We are unable on the basis of this EIS to determine the least environmentally damaging practicable alternative which fulfills the project purpose of flood protection.

Based upon the above concerns, we have classified this DEIS as category EC-2, Environmental Concerns - Insufficient Information (see attached "Summary of the EPA Rating System"). Our detailed comments are enclosed. These comments are based upon the assumption of full implementation of all proposed mitigation measures.

We appreciate the opportunity to review this DEIS. Please send three copies of the Final EIS to this office at the same time it is officially filed with our Washington, D.C. office. If you have any questions, please call Jacqueline Wyland, Chief, Office of Federal Activities, (415) 744-1584, (FTS 484-1584) or Laura Fujii, of her staff, at (415) 744-1579, (FTS 484-1579).

Sincerely,

Jacqueline Wyland

for Deanna Wieman, Director
Office of External Affairs

Enclosure: (11 pages)

Filename: SACFLOOD\SACMETRO
91-299
MI000177

cc: COE, Sacramento, Walter Yep
COE, San Francisco, Frank Dunn
OASA, Washington, D.C., Morgan Rees
BOR, Sacramento, Roger Patterson
DOI, San Francisco, Patricia Port
FWS, Sacramento, Wayne White
NMFS, Santa Rosa, James Bybee
FEMA, Regional Director
DWR, Sacramento, David Kennedy
CA Reclamation Board, Wallace McCormack
CDFG, Region 2, Jim Messersmith
SWRCB, Sacramento, Donald Maughan
RWQCB, Region 5, William Crooks
ARB, Jim Boyd
SCAPCD, Sacramento
SACOG, James Williams
SAFCA, Bill Edgar
HQ EPA: OFA, OWP

SUMMARY OF RATING DEFINITIONS
AND FOLLOW-UP ACTION*

Environmental Impact of the Action

LO--Lack of Objections
The EPA review has not identified any potential environmental impacts requiring substantive changes to the proposal. The review may have disclosed opportunities for application of mitigation measures that could be accomplished with no more than minor changes to the proposal.

EC--Environmental Concerns
The EPA review has identified environmental impacts that should be avoided in order to fully protect the environment. Corrective measures may require changes to the preferred alternative or application of mitigation measures that can reduce the environmental impact. EPA would like to work with the lead agency to reduce these impacts.

EO--Environmental Objections
The EPA review has identified significant environmental impacts that must be avoided in order to provide adequate protection for the environment. Corrective measures may require substantial changes to the preferred alterna tive or consideration of some other project alternative (including the no action alternative or a new alternative). EPA intends to work with the lead agency to reduce these impacts.

EU--Environmentally Unsatisfactory
The EPA review has identified adverse environmental impacts that are of sufficient magnitude that they are unsatisfactory from the standpoint of public health or welfare or environmental quality. EPA intends to work with the lead agency to reduce these impacts. If the potential unsatisfactory impacts are not corrected at the final EIS stage, this proposal will be recommended for referral to the CEQ.

Adequacy of the Impact Statement

Category 1--Adequate
EPA believes the draft EIS adequately sets forth the environmental impact(s) of the preferred alternative and those of the alternatives reasonably avail able to the project or action. No further analysis or data collection is necessary, but the reviewer may suggest the addition of clarifying language or information.

Category 2--Insufficient Information
The draft EIS does not contain sufficient information for EPA to fully assess environmental impacts that should be avoided in order to fully protect the environment, or the EPA reviewer has identified new reasonably available alternatives that are within the spectrum of alternatives analyzed in the draft EIS, which could reduce the environmental impacts of the action. The identified additional information, data, analyses, or discussion should be included in the final EIS.

Category 3--Inadequate
EPA does not believe that the draft EIS adequately assesses potentially significant environmental impacts of the action, or the EPA reviewer has identified new, reasonably available alternatives that are outside of the spectrum of alternatives analyzed in the draft EIS, which should be analyzed in order to reduce the potentially significant environmental impacts. EPA believes that the identified additional information, data, analyses, or discussions are of such a magnitude that they should have full public review at a draft stage. EPA does not believe that the draft EIS is adequate for the purposes of the NEPA and/or Section 309 review, and thus should be formally revised and made available for public comment in a supplemental or revised draft EIS. On the basis of the potential significant impacts involved, this proposal could be a candidate for referral to the CEQ.

*From EPA Manual 1640 Policy and Procedures for the Review of Federal Actions Impacting the Environment.

Figure 4-1

COMMENTS

NATIONAL ENVIRONMENTAL POLICY ACT

A. Insufficient Information

Disparities Between U.S Fish and Wildlife Service and Corps of Engineers Environmental Impact Analyses

It is our understanding that there are still major disagreements between the COE and US Fish and Wildlife Service (USFWS) in regards to direct and indirect impacts and mitigation requirements (DEIS Appendix B Draft USFWS Coordination Act Report). Should the COE and USFWS continue to disagree regarding the level of impact and quality and quantity of mitigation required, the FEIS should provide a more detailed explanation of the underlying impact and land use assumptions and land use projections causing this disagreement and a table clearly illustrating the differences in the agencies' assumptions and numerical conclusions.

B. Alternatives Analysis

1. We recognize and understand the guidance directing the COE to develop the National Economic Development (NED) plan as an objective of the project (Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, March 10, 1983 pursuant to Section 103 of the Water Resources Planning Act, as amended). Nevertheless, we are concerned that this objective may have unnecessarily limited the scope of flood control measures considered acceptable and feasible, especially if these measures are evaluated solely against the NED criteria of completeness, effectiveness, efficiency and acceptability (Feasibility Report (FR) pgs. 37-39).

2. The COE has not persuasively demonstrated that eliminated flood control measures (FR pgs. 39-43) are not practicable or feasible. Rejected flood control measures, while they may not individually provide full FEMA level of flood protection, may be used in combination with other measures to provide the necessary flood protection with fewer environmental impacts than the proposed project. For example, the DEIS does not describe the possible use of floodwalls, cutoff walls, and flood easements to reduce the flood risk to existing and future developments. Many of the eliminated measures have been discounted as economically infeasible or environmentally damaging with little supporting data. The FEIS should provide additional data to substantiate the conclusion of infeasibility. Levels of protection, costs and impacts of flood control measures which were dropped need to be provided.

3. The DEIS states that 200-year level of flood protection is the State and local sponsors' preferred level of protection for the Sacramento areas which would be at risk from flooding on the American River (American River Watershed Investigation project, FR pg. 46). Given the close interrelationship between the American River and Sacramento Metropolitan projects, it appears somewhat inconsistent to provide different levels of protection for the Cities of Sacramento and West Sacramento. We recommend the FEIS provide more information on the rationale for different levels of flood protection and an evaluation of the consequences of these differences on flood protection for the greater Sacramento area.

4. It is our understanding that State and local sponsors have requested 400-year level of flood protection because of urbanization already within and beyond the 100-year flood plain and expected growth in the area. We hope the COE will continue to work with project sponsors to evaluate mechanisms beyond levee construction available to State and local sponsors to provide 100-year or greater levels of flood protection. These actions should be described in the FEIS in accordance with the provisions of the NEPA regulations to consider alternatives beyond those for which the Federal sponsor has direct authority (40 CFR Section 1502.14(c)) and to ensure compliance with the 404(b)(1) Guidelines. We believe this approach is further supported by Executive Order 11988 on Flood Plain Management and Executive Order 11990 for Protection of Wetlands, which exhort Federal agencies to provide leadership and take action to restore and preserve the natural and beneficial values served by flood plains and to consider alternatives to avoid adverse effects and incompatible development in flood plains and wetlands.

C. Mitigation

1. We are pleased that the COE is committed to full mitigation for direct impacts of the selected alternative. However, we are very concerned that the COE does not plan to mitigate for indirect impacts. The DEIS does not appear consistent in this respect with the February 7, 1990 guidance provided by General Hatch in his transmittal of the EPA/COE MOA on Mitigation to COE offices. That MOA does not distinguish between direct and indirect impacts. Although we understand that mitigation for direct impacts only is a COE policy, we request the COE address the derivation of this policy and whether it is consistent with the understanding reached between HQ EPA and the COE during the CEQ referral of COE NEPA Regulations.

State and local responsibility for indirect impact mitigation does not obviate the necessity for the COE's DEIS to fully disclose mitigation measures for indirect and cumulative impacts and evaluate the feasibility of their implementation,

even if they are outside the jurisdiction of the COE (40 CFR Sections 1502.14(f), 1502.16(h), 1508.8, and 1508.20; March 16 1981 CEQ Memorandum - Questions and Answers About the NEPA Regulations, Question 19 Mitigation Measures). Therefore, mitigation plans should be described in the FEIS.

As stated by the DEIS, mitigation for impacts associated with long-term growth is not usually coordinated on a regional level and is often unsuccessful in fully reducing impacts below a level of significance (DEIS pg. 22-5). We believe up-front mitigation for cumulative impacts or establishment and contributions to development of a mitigation bank, would provide effective and flexible means to compensate for specific resources
2. likely to be degraded or destroyed by the project. We also believe mitigation may be necessary for temporary impacts since construction will take place over a 2 year period and temporarily impact 149.8 acres of upland vegetation (DEIS pg. 8-6). We recommend that mitigation plans for direct, indirect, and temporary impacts be addressed in the FEIS and that such plans be fully coordinated with resource agencies prior to finalization.

WATER RESOURCES

A. Section 404 of the Clean Water Act

Alternatives Analysis and Practicability

1. EPA is concerned that the plan selection and alternatives analysis was performed pursuant to the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (National Economic Development (NED) Guidelines) prior to analysis pursuant to the Clean Water Act Section 404(b)(1) Guidelines. We are concerned that the COE may have inappropriately limited the flood control measures and number of feasible alternatives retained for further study. Measures which may be less-damaging but which may satisfy the basic project purpose of flood control may have been dropped without adequate information for the public or decision makers to determine whether these measures are practicable under Section 404.

2. EPA supports public health and safety and acknowledges the need for local support of a selected flood protection alternative. Nevertheless, in the case of a project requiring a Section 404 permit, a permit can only be issued for the least-damaging practicable alternative which provides a reasonable level of flood protection. The COE should document whether there are less environmentally damaging flood protection alternatives, even though they may not be supported by the local sponsor or satisfy NED requirements.

3. The applicant proposes to provide 400-year level of flood protection to the West Sacramento area. EPA is concerned that the COE may not have sufficiently addressed less damaging alternatives which would meet the federal standard of 100-year flood protection for existing development. We note that the County of Sacramento is proposing flood protection in the North Natomas area (Corps Public Notice 9000479) for a 100-year storm event.

EPA believes the DEIS does not sufficiently address alternatives to the preferred alternative. The document evaluates in detail three levels of flood protection achieved by raising existing levees. The FEIS should expand the alternatives analysis to address in more detail other structural, non-structural, and combination alternatives (cutoff walls, floodwalls, additional flood easements, flood proofing in combination with other measures). In addition the FEIS should evaluate whether the proposed alternatives could be further modified to reduce their impacts.

4. Many of the potential alternatives were dropped from further consideration based on cost, environmental impact and hydraulic effectiveness (DEIS pg. 3-1). Although these factors may be used in determining the practicability of the proposed alternatives, sufficient substantiating information for these conclusions is not provided. The FEIS should evaluate whether alternatives were eliminated because they did not provide the maximum hydraulic effectiveness and whether costs associated with eliminated alternatives were prohibitive.

Specific comments

1. The FEIS should provide a table showing the alternatives and the acreage of direct and indirect impacts to jurisdictional aquatic and non-jurisdictional wetlands.

2. The level of current flood protection for the study area is not clear. Appendix B of the Feasibility Report (FR Appendix B pgs. 12, 26) states that the City of West Sacramento has 90-year level of flood protection, while the Feasibility Report (FR pg. 26) states there is 70-year level of protection. The FEIS should clearly state the current level of flood protection for the area in both FEMA and COE terms.

3. Appendix B of the Feasibility Report uses a 50 year project life for the evaluation of benefits and costs of the project. Benefits and costs of the project should be evaluated based on a project life of 100 years. The FEIS should show how the economic analysis for each of the alternatives is affected by this change in project life.

4. The FEIS should evaluate whether the levee base can be decreased or other mechanisms used (e.g., cutoff walls) to reduce wetland impacts. It is not clear whether the levee width is proposed in order to allow for a minimum crest width of 20-feet.

Water Quality and Endangered Species

1. To comply with the 404(b)(1) Guidelines, the proposed project must not violate water quality standards, toxic effluent standards, or jeopardize the continued existence of federally listed species or their critical habitat (40 CFR 230.10(b)). The proposed project may result in adverse impacts to federal and state threatened and endangered species such as the valley elderberry longhorn beetle and Swainson's hawk. In addition, the state listed, federal candidate species giant garter snake may be significantly affected by indirect impacts of the project (i.e., increased development). Close coordination with the US Fish and Wildlife Service (USFWS) and California Department of Fish and Game should continue to ensure the continued existence of the valley elderberry longhorn beetle, giant garter snake, and Swainson's hawk is not jeopardized by the proposed project and that potential impacts to sensitive species are minimized.

Significant Degradation

1. The COE does not clearly state the level of direct and indirect impacts to wetlands. Potential impact values which are presented in the Feasibility Report, DEIS and Appendices are inconsistent, describing direct impacts to wetlands of 11.9 to 40 acres and indirect impacts of 81 to 1233 acres. The FEIS should consistently reflect the potential impacts to wetlands and other resources.

2. The COE states that toe drains should be backfilled if they are within 50-feet of the levee toe (FR Appendix E pg. 6). Although the COE does not currently believe that toe drains will need to be relocated, they have committed to additional supplemental documentation if relocation is found to be required (DEIS pg. 8-5). This future documentation should include an alternative analysis, acreage of impact, habitat type to be lost, and proposed mitigation.

3. The FEIS should address in more detail the impacts associated with use of the borrow sites. In addition, the borrow material should be tested for contaminates and the results reported in the FEIS. The borrow site evaluation should describe potential alternative sites if the proposed sites prove unsuitable.

Mitigation

1. Although we commend the COE for their commitment to full mitigation for direct impacts, we are very concerned that the COE does not plan to support mitigation for indirect impacts. These indirect impacts are expected to be substantial. We believe actions should be taken at this time to help avoid or compensate for these indirect losses. EPA is concerned that evaluation of potential impacts of future development on a project by project basis may result in unmitigated losses. We are also concerned with the major disparity between the USFWS and COE potential impact and mitigation findings. We urge the COE to work with the USFWS, State and local sponsors to fully address mitigation for indirect impacts of the project.

Specific Comments

1. EPA's mitigation goal is no net loss of in-kind acres, functions and values for aquatic habitats. Habitat types that should be created in the mitigation site include riparian forest, emergent marsh, and scrub/shrub habitat. The DEIS indicates that the amount of each habitat type to be created will be determined during the project design stage. Utilizing the wetland delineation, the COE should be able to determine at this time the habitat types which will be lost and must be replaced through mitigation. The FEIS should clearly describe the acreage of each habitat type to be included as mitigation.

2. EPA is concerned with the potential use of mitigation Site C. Site C has been used for dredge spoils and should be evaluated for contamination. Furthermore, the FEIS should address the location of future dredged disposal sites and potential impacts to these sites, if Site C is no longer available for dredge disposal.

3. It is unclear whether water is available for mitigation Site D. A mitigation site should be able to function naturally, without long term reliance on pumping or irrigation features for the water supply. The FEIS should also include more information on the long-range development proposed for Site D which is alluded to in the DEIS (DEIS pg. 8-12).

4. EPA recommends that plants to be impacted by the proposed project be salvaged for replanting at the mitigation site.

5. EPA encourages the COE and project sponsor to consider the Avoidance measures suggested by the USFWS in their Draft Coordination Act Report (DEIS Appendix B pg. 81). These measures would help reduce impacts to fish and wildlife and reduce mitigation requirements and costs.

6. The FEIS should provide more information on the rationale for using primarily aquatic related species to evaluate upland impacts in the HEP (DEIS pg. 10-2).

7. DEIS Appendix D 404(b)(1) Water Quality Evaluation, states under the cumulative effects determination that most effects would be temporary, minor, or within acceptable limits (DEIS Appendix D pg. 11). Although effects of the proposed project may be temporary or minor, there are a number of large flood control projects being proposed for the Sacramento area. Potential cumulative impacts could be significant, as clearly stated in the DEIS (DEIS pg. 1-6). Appendix D should be revised to accurately evaluate the cumulative impacts of the proposed project.

General Comments

1. DEIS Appendix D 404(b)(1) Water Quality Evaluation, states that there are no wetlands within the project area (DEIS Appendix D pg. 10). This statement is in direct conflict with information in the Feasibility Report (FR pg 71) and DEIS (DEIS pg. 8-3) which clearly state there will be a loss of 11.9 acres of wetlands caused by direct project impacts. The FEIS should explain this discrepancy.

B. Floodplain Management

1. The DEIS indicates that the Elkhorn area, located north of the current study area, was initially included in the Sacramento Metropolitan Area study. Analyses based on existing development indicated that alternatives to increase this area's level of flood protection were not cost-effective and therefore infeasible. As a result, in coordination with the local sponsor and concurrent with local progress towards future development of the area, the COE has transferred the Elkhorn area to the Yolo Bypass Reconnaissance study to provide sufficient time for the local sponsor to provide information on future development and the potential for additional benefits that could be used in cost-benefit analyses (DEIS pg. 2-5).

Although EPA supports the protection of existing property and structures from flood damage, we are concerned with the appropriateness of the above action given the direction to Federal Agencies by Executive Order 11988, Floodplain Management, to avoid direct or indirect support of flood plain development wherever there are practicable alternatives. The FEIS should clearly demonstrate that the transfer of the Elkhorn area to a later project and reevaluation of cost-benefit analyses has not encouraged future development in order to qualify the area for federally supported increased flood protection.

AIR QUALITY

The Sacramento area has serious air pollution problems which the proposed project may increase. Sacramento County is currently designated nonattainment for ozone, carbon monoxide and fine particulate matter. Given the potential significant impacts to air quality we are concerned with cumulative air impacts and the adequacy of mitigation. The FEIS must clearly demonstrate that the proposed action would not delay timely attainment of National Ambient Air Quality Standards (NAAQS) or contribute to violations of the NAAQS.

Conformity Pursuant to the 1990 Clean Air Act Amendments

2\. The DEIS lacks a conformity demonstration as required by Section 176(c) of the Clean Air Act. Although the DEIS provides a general assessment of impacts and acknowledges significant future air quality impacts, it does not provide supporting evidence that proposed alternatives meet the conformity requirements of 1990 Clean Air Act Amendments. Section 176(c)(1) provides that:

> No department, agency, or instrumentality of the Federal Government shall engage in, support in any way or provide financial assistance for, license or permit, or approve any activity which does not conform to an implementation plan after it has been approved or promulgated under section 110...Conformity to an implementation plan means:
>
> (A) Conformity to an implementation plan's purpose of eliminating or reducing the severity and number of violations of the national ambient air quality standards, and achieving expeditious attainment of such standards;
>
> (B) That such activities will not--
>
> (i) cause or contribute to any new violation of any standard in any area;
> (ii) increase the frequency or severity of any existing violation of any standard in any area; or
> (iii) delay timely attainment of any standard or required interim emission reductions or other milestones in any area."

We urge the COE to consult the Sacramento County Air Pollution Control District and Air Resources Board to ensure their proposed action conforms to current planning efforts towards attainment of air quality standards.

Assessment of Air Quality Impacts

A. The DEIS does not provide a substantive analysis of whether the projected direct and indirect impacts will interfere with expeditious attainment of national ambient air quality standards or contribute to standards violations in the Sacramento Valley. Nor does the air quality evaluation address the issue of fine particulate matter (PM10). The air quality analysis should address the cumulative effects on air quality expected from development identified to occur once flood protection is provided to the City of West Sacramento.

1) The analysis should discuss potential changes in population, employment, vehicle miles traveled, and additional trips taken. Transportation projects proposed as mitigation for transportation impacts should be accompanied by an analysis of their potential impacts on air quality, particularly where these projects might induce development in other parts of the region. These transportation projects should be part of a conforming transportation plan.

2) The analysis should project potential emissions increases in carbon monoxide (CO), hydrocarbons (HC), particulate matter (PM10), and NOx resulting from increased population, increased vehicle miles traveled, added trips, as well as added point and area sources of air pollutants.

3) The analysis should also discuss the ozone impacts resulting from increased emissions of HC and NOx and identify CO hot spots in consultation with the local agencies. It should further discuss the impacts of the NOx and SOx emission increases on the related ambient air quality standards.

Mitigation of Impacts to Air Quality

1. The COE should develop with local agencies a mitigation plan to ensure conformity with the Clean Air Act. The memorandum of understanding (MOU) proposed for the American River Watershed Investigation project may serve as a model instrument for developing this mitigation plan. The MOU portion for air quality mitigation should be expanded to include Yolo, Solano, Placer, and El Dorado Counties in addition to Sacramento and Sutter Counties. EPA is willing to work with MOU participants to develop a mitigation plan and to ensure that mitigation measures are implemented.

GENERAL COMMENTS

1. There are minor typographical errors and inconsistencies throughout the Feasibility Report and DEIS. While not a problem individually, collectively these items cause confusion and

detract from the effective transfer of information. For example, the Appendices are not consistent with the Feasibility Report and DEIS in their description of project features, existing conditions, or alternatives evaluated in detail. Other areas of confusion are the utilization of different sets of appendices for the Feasibility Report and DEIS (these should be distinguished in some way) and the use of Plates with both alpha and numeric designations (clearly state that the Plates being referenced are in the back of the Feasibility Report versus those scattered throughout the Report).

2. EPA believes there may be evidence to document windfall benefits and the need for special cost sharing arrangements. We urge the COE to carefully evaluate the benefits of the project and to consider special cost sharing arrangements if appropriate. Windfall benefits are possible when a project would provide to just a few beneficiaries those locational benefits attributable to relief from flood plain development restrictions. Sixteen landowners own 83% of the acreage which would receive locational benefits (DEIS pg. 2-8). These benefits would raise the cost/benefit ratio from 4.9/1 (existing development only) to 5.7/1 (existing and future development) (FR pg. 73).

3. FR pg. 14. The FEIS description of the Bureau of Reclamation's (BOR) multipurpose Auburn Dam project should include information on the current actions and studies being taken by BOR on this project.

4. FR pg. 45. We recommend the final Feasibility Report include a list of the local flood control projects which the Report assumes will be in place under the without-project condition.

5. FR pg. 53. The Feasibility Report appears to utilize two standards for determining levee failure. For instance, the hydraulic damage analysis (FR pg. 53) assumes failure on encroachment of the water surface halfway into the design freeboard while volume-frequency curves assume no levee failure until design flows have been exceeded (FR pg. 48). The final Feasibility Report should indicate whether these two assumptions are the same or justify the use of different assumptions.

6. The COE should provide specific information on the season, year and meteorological conditions under which fish, wildlife, and endangered species surveys were made. Also indicate the number of surveys conducted and the general methodology used.

RESPONSE TO EPA COMMENTS

Sacramento Metropolitan Area Study

1. The following justification is provided in response to EPA's comment that in order to ensure consistent decisions, evaluation, and approval of projects which provide necessary components for future actions should be accomplished prior to, or in close parallel with, approval of the future action. Specifically EPA refers to the American River project, Sacramento Systems Evaluation and Sacramento Metropolitan Study.

Response: It is the Corps contention that these projects are independent although hydrologically interrelated therefore, separate independent EIR/EIS for each project provides the most accurate and complete environmental impact evaluation. In addition, each document presents cumulative impacts associated with providing flood control to the total system thereby, interrelating each individual project to each other and finally to the total system. Consequently, because these projects can function independently it is not inconsistent to analyze them separately.

2. EPA has stated that they believe it may have been more appropriate to have considered the Sacramento Metropolitan project as a component of the American River Watershed Investigation project.

Response: Although the American River project does not assume the Sacramento Metropolitan project in place it does analyze its impacts under the EIR/EIS cumulative impacts analysis. The Sacramento Metropolitan Study assumes the American River project in place under both "with-" and "without-project" conditions. This assumption is justified based on the very high likelihood of obtaining flood control for the City of Sacramento in the near future. In addition, the Sacramento Metropolitan Study also analyzes the impacts of not having a flood control project in place on the American River. The analysis indicated that the Sacramento Metropolitan project would still be feasible even without the American River flood control dam however, it would provide a 150-year level of protection as opposed to a 400-year level of protection.

3. The Agency contends that the DEIS/EIR fails to, "rigorously explore and objectively evaluate all alternatives" (40 CFR section 1502.14(a)).

Response: A full range of alternatives have been examined to meet the project purpose. These alternatives include nonstructural and structural options as well as options providing varying levels of flood protection. The Corps has made no attempt to limit the scope of alternatives nor its evaluation of those alternatives. These

alternatives are discussed in Chapter IV of the feasibility report. We believe the analysis conducted under Federal Principle and Guidelines fully evaluates all feasible alternatives.

4. The EIR/EIS does not sufficiently discuss compliance with environmental statutes including the Clean Water Act and Clean Air Act (40 CFR section 1502.16, 1506.2(d), and 1508.8).

RESPONSE: The discussion in Chapter 24 of the EIS/EIR explains how the project is in compliance with all applicable laws, regulations, policies, guidelines, and plans. Chapters 6 and 7 discuss water quality and air quality issues, impacts and mitigation.

5. EPA contends the DEIS/EIR does not sufficiently discuss the means to mitigate adverse direct, indirect, and cumulative impacts (40 CFR 1508.2). EPA states that the DEIS outlines possible mitigation for direct impacts, however, there is limited information on mitigation for indirect and cumulative impacts.

Response: In most resource areas, specific mitigation measures have been elaborated upon in the EIS/EIR. Chapter 23 contains a complete summary of project mitigation measures. The adoption of specific mitigation measures under NEPA and CEQA, however, does not occur until the lead agency makes findings and renders its decision to approve or carry out a project. Moreover, with respect to secondary impacts, it is appropriate on a practical level to implement mitigation through those agencies with local land use authority. This approach is consistent with NEPA and CEQA.

The Selected Plan includes requirements to mitigate for direct project impacts. Any requirements to mitigate for impacts of induced future development will be the responsibility of the local agencies controlling development in the project area. Since the extent and timing of these indirect impacts will be determined in the context of the local land use planning process, it is appropriate that this process address mitigation issues as well. The local agencies are expected to provide assurances as to how they will exercise their planning authority to avoid or minimize indirect impacts. These assurances are discussed in Chapter 22 of the EIS/EIR. The State and local interests have provided their plans for mitigation of growth-inducing impacts as part of the mitigation plan.

6. EPA has commented on their concern regarding comment regarding particular disparities between U.S. Fish and Wildlife Service and Corps of Engineers environmental impact analysis.

RESPONSE: The Corps land use analysis followed standard procedures for developing their assessments of flood damages, and project benefits and costs. The FWS used information in the West Sacramento General Plan as a basis for future land use predictions. The mitigation proposed for the project has been deemed reasonable

and justifiable.

7. EPA has stated that they are unable, on the basis of the EIS, to determine the least environmentally damaging practicable alternative which fulfills the project purpose of flood protection. In addition, EPA has stated that the Corps must fully consider the 404(b)(1) guidelines in the EIS.

Response: Federal Principles and Guidelines and Clean Water Act guidelines are adequately satisfied in the selection of the 400-year alternative. As stipulated under Principles and Guidelines, plan formulation was carried out consistent with applicable environmental laws, including the Clean Water Act. The EIS/EIR has been revised to include a more precise discussion of the Section 404 Evaluation which identifies the least environmentally damaging practicable alternative. The Corps feels that this revised discussion more fully substantiates compliance with the Clean Water Act, 404(b)(10) guidelines and will allow EPA to make a positive determination of compliance.

<u>Attached General Comments</u>

A. <u>Insufficient Information</u>

It is EPA's understanding that there exists disparities between U.S. Fish and Wildlife Service and Corps of Engineers in regards to direct and indirect impacts and mitigation requirements.

It is EPA's understanding that there are still major disagreements between the COE and U.S. Fish and Wildlife Service (USFWS) in regards to direct and indirect impacts and mitigation requirements (DEIS Appendix B Draft USFWS Coordination Act Report). Should the COE and USFWS continue to disagree regarding the level of impact and quality and quantity of mitigation required, the FEIS should provide a more detailed explanation of the underlying impact and land use assumptions and land use projections causing this disagreement and a table clearly illustrating the differences in the agencies' assumptions and numerical conclusions.

Response: There are no major disagreements between the COE and USFWS regarding direct impacts.

In regards to the differences in indirect impact projections by the FWS and COE, the FWS assumed a worst-case scenario for buildout under the General Plan. The calculations assume full buildout of virtually all lands. The COE assumed a more conservative scenario based on State of California Department of Finance projections, discussions with local planners, and land availability. In the General Plan there are statements to the affect that development may not be realized in the time frame of their General Plan. The General Plan specifically states "whether all of this potential development will actually occur during the time frame of the

General Plan (1988 to 2010) is speculative. For some land use categories such as commercial office, and heavy industrial, full buildout may not be realized for many years beyond the time frame of the General Plan". In addition, the General Plan qualifies it's future land use projections with the following statement, "The rate at which West Sacramento's vacant land will be absorbed or converted to urban uses will be largely dictated by market conditions and the availability of public services and facilities, particularly access to the Southport area." Finally, the extent and timing of indirect impacts will ultimately be determined in the context of the local land use planning process. The local agencies are expected to provide assurance as to how they will exercise their planning authority to avoid or minimize indirect impacts. These assurances are discussed in Chapter 22 of the EIS/EIR. The land use assumptions are outlined in Appendix A - Land Use and Chapter 5 of the EIR/EIS.

B. Alternative Analysis

1. EPA has stated they are concerned that application of the National Economic Development Plan as an objective of the project may have unnecessarily limited the scope of flood control measures considered.

Response: It is the Corps contention that flood control projects are analyzed on the basis of Federal Principle and Guidelines. Under these guidelines the formulation of alternative plans leading to the identification of the NED Plan inherently includes environmental considerations. Consequently the very nature of the selection process governed by Federal Principle and Guidelines does not treat environmental criteria in a subordinate manner. Therefore, the Corps has not inappropriately eliminated less environmentally damaging flood control measures or feasible alternatives by applying Principle and Guidelines.

2. EPA has stated that the Corps has not persuasively demonstrated that eliminated flood control measures are not practicable or feasible. For example, the DEIS does not describe the possible use of floodwalls, cutoff walls, and flood casements to reduce the risk of flooding.

Response: The Corps feels a full range of alternatives were examined to meet project purposes. These alternatives include nonstructural and structural options.

The purpose of the Sacramento Metropolitan Study is to provide increased levels of flood protection to the existing development in West Sacramento. Two of the alternatives mentioned in this comment will not reduce flood risk to existing development. Cutoff walls are used to reduce or eliminate seepage through a levee. Seepage can create stability problems and cause a levee to be weak.

Seepage is not a problem with the Yolo Bypass levees. Cutoff walls do not increase the level of flood easements and do not decrease flood risk to existing development. Flood easements prevent damage to future development by requiring that development to occur in other less flood prone areas. The largest majority of Sacramento Metropolitan project benefits are for protection to existing development. The surest and most cost effective way to increase flood protection for the existing development in West Sacramento is to raise the existing levees which surround the area. Levees can be raised by adding embankment material to the top and sides of the levee or by building floodwalls on the top of the levee. If levee height increase are small, floodwalls may be more economical that additional embankment. However, for the Sacramento Metropolitan Study, levee increases are on the average of five feet. A flood wall requires a footing which must be covered by soil to provide adequate stability. A visible five foot floodwall could have an additional two to three feet of wall beneath the ground with a ten foot wide footing. This requires the top three feet of the levee to be excavated to construct the wall. The placement of a floodwall may not leave enough crest width to properly maintain or inspect the levee which would require increasing the existing crest width which would cause widening of the levee base. Many people consider floodwalls to be more aesthetically objectionable than grass covered earth embankments. Finally, the construction of floodwalls are much more expensive that placing additional embankment. For all of these reasons it was determined that adding additional embankment to the existing levees was more economically viable than using floodwalls.

3. EPA has stated that given the close interrelationship between the American River and Sacramento Metropolitan projects it appears somewhat inconsistent to provide different levels of protection for the Cities of Sacramento and West Sacramento.

Response: Both the draft documents for the American River Watershed Investigation (ARWI) and the Sacramento Metropolitan Study identified the 400-year alternative as the National Economic Development (NED) plan and the Tentatively Selected Plan. However, in the case of the ARWI, the local sponsor requested the 200-year alternative as the selected plan based on cost considerations and environmental acceptability. In the case of the Sacramento Metropolitan Study the local sponsor has indicated that the 400-year alternative is the preferred plan. The American River 200-year Selected Plan does not adversely impact West Sacramento's proposed 400-year project and vice-versa. Therefore, because these flood control projects can function independently it is not inconsistent to provide different levels of flood protection for the Cities of Sacramento and West Sacramento.

4. EPA has stated that the local sponsor has requested a 400-year level of flood protection. However, EPA continues by stating that "they hope the Corps will continue to work with the project sponsor

to evaluate mechanisms beyond levee construction available to state and local sponsors to provide 100-year or greater levels of flood protection". These actions should be described in the DEIS in accordance with the provisions of the NEPA regulations to consider all alternatives beyond those for which the Federal sponsor has direct authority and to ensure compliance with 404(b)(1) Guidelines. EPA believes this approach is further supported by Executive Order 11988 on Flood Plain Management and Executive Order 11990 for protection of wetlands.

Response: The Corps in conjunction with the local sponsor has evaluated mechanisms beyond levee construction to provide 100-year or greater levels of flood protection. Based upon these evaluations, which considered Executive Order 11988 and 11990 the local sponsor has determined that the 400-year level of flood protection is in their best interest. The document contains a local cost sharing agreement which attests to this fact. Further consultation to evaluate other mechanisms is not appropriate at this time.

C. Mitigation

1. EPA states that the DEIS does not appear consistent in respect to the February 7, 1990 guidance provided by General Hatch regarding mitigation for indirect impacts. EPA requests the Corps to address the deviation of this policy and whether it is consistent with the understanding reached between HQ EPA and the COE. In addition, State and local responsibility for indirect impact mitigation does not obviate the necessity for the COE's DEIS to fully disclose mitigation measures for indirect and cumulative impacts and evaluate the feasibility of their implementation, even if they are outside the jurisdiction of the COE. EPA also believes upfront mitigation for cumulative impacts would provide an effective means of mitigation.

Response: The EPA/COE Memorandum of Agreement on mitigation requirements and the related February 7, 1990 guidance applies only to Corps regulatory functions. This is clearly established in the Memorandum of Agreement between the COE and EPA. The Corps is committed to full mitigation for direct impacts on significant resources. Direct impacts related to a proposed project are impacts that are fully expected to occur as a direct result of project implementation. Indirect and cumulative impacts are those impacts which may occur as a result of a project and, in addition, may only occur due to actions taken by others later in time following implementation of the project. And, accordingly, the responsibility for determining the extent of such impact and mitigation needs rests with those that will approve/disapprove of the later actions causing the impact. The EPA/COE MOA on mitigation applies to Corps 404 permits and not to the civil works program such as this proposed project.

In preparing and EIS, the COE has responsibility to predict, to the best of its ability, potential indirect and cumulative impacts related to a project, and accompanying potential mitigation measures. They are disclosed in the EIS/EIR. Such disclosure provides an estimate of potential long-term impacts that may occur as a result of the project. This allows the decision-maker to make an informed decision regarding implementation of the project. These predicted impacts may never occur in the future, or they may be more adverse than predicted. Up-front mitigation of indirect and cumulative impacts provides no guarantee of satisfying the intent of mitigation, that is, to provide no net loss of environmental values. Actual impacts may be totally different than the predicted indirect impacts.

Consequently, the Corps' policy for indirect impact mitigation is the most appropriate to assure mitigation of actual indirect and cumulative impacts that may occur in the future. In this policy, a nonfederal sponsor, who has the authority to implement public policy which affects these "indirect impacts", takes on responsibility for indirect impact mitigation. This allows for continuous evaluation and consideration to avoid the impact and/or provide for adequate mitigation if unavoidable.

2. EPA believes mitigation for temporary impacts may be necessary since construction will take place over a 2 year period and temporarily impact 149.8 acres of upland vegetation (DEIS pg. 8-5).

Response: Comment noted revised text in Chapter 8, Section 8.2.2.

Water Resources

A. Section 404 of Clean Water Act

Alternative Analysis and Practicability

1. EPA is concerned that the plan selection and alternative analysis was performed pursuant to the Economic and Environmental Principles and Guidelines for Water and Related Land Resource Implementation Studies (National Economic Development [NED] Guidelines) prior to analysis pursuant to the Clean Water Act Section 404 (b)(1) Guidelines. This may have inappropriately limited the flood control measures and feasible alternatives retained for further study.

Response: It is the Corps contention that flood control projects are analyzed on the basis of Federal Principle and Guidelines. Under these guidelines the formulation of alternative plans leading to the identification of the NED Plan inherently includes environmental considerations. Consequently the very nature of the selection process governed by Federal Principle and Guidelines does not treat environmental criteria in a subordinate manner. Therefore, the Corps has not inappropriately eliminated less

environmentally damaging flood control measures or feasible alternatives by applying Principle and Guidelines.

2. EPA has commented that in the case of a project requiring a section 404 permit, a permit can only be issued for the least-damaging practicable alternative which provides a reasonable level of flood protection. The COE should document whether there are less environmentally damaging flood protection alternatives even though they may not be supported by the local sponsor or satisfy NED requirements.

Response: Description of the environmental analysis leading to identification of the least environmentally damaging alternative has been described in Chapter 2 of the EIR/EIS. Additional discussion of this topic is found in Appendix D (404 Appendix).

3. EPA is concerned that the COE may not have sufficiently addressed less damaging alternatives which would meet federal standards of 100-year flood protection for existing development. EPA notes that the county of Sacramento is proposing flood protection in the North Natomas area for a 100-year storm event.

EPA has commented that "the County of Sacramento is proposing flood protection in the North Natomas area (Corps Public Notice 9000479) for a 100-year event."

Response: In the plan formulation process the feasibility report and accompanying EIS/EIR analyze the feasibility and associated impacts of providing 100-year flood protection to the City of West Sacramento. Some consideration was given to the potential for developing alternatives that would protect the existing development of West Sacramento while leaving agricultural land intact. Possible alternatives were ring levees and cross levees. However, further study determined that there are no strategic locations in the vicinity of West Sacramento or Southport to construct cross levees or ring levees which would protect only urbanized areas. In addition, due to the physical geography of the area raising the existing levees provides a high level of protection to both the urbanized area and agricultural sections inclusively.

The most viable and economically feasible method to accomplish flood control is to raise the existing levee. The local sponsor in conjunction with the COE believes that because all of West Sacramento lies within the flood plain, and is inhabited by approximately 30,000 people a project is required to offset the significant flood risk to existing residential, commercial, and industrial development. The appropriate level of flood protection for the Sacramento Area is based upon economic public health and safety, local acceptability criteria and environmental factors. The non-federal sponsor for this project has indicated that they feel a 400-year level of protection is appropriate considering all these factors but primarily considering the significant flood depth

which would be experienced and the reliance on high earthen levees for protection. It should be noted there is not a "federal standard" of 100-year level protection.

Review of Public Notice 9000479 indicates that the subject of this Notice is the City of Sacramento's application for a 404 permit to construct internal drainage facilities in the North Natomas area. This proposed project is not an attempt by the City to provide 100-year flood protection to the area but rather an upgrading to the existing North Natomas Community drainage system. The design criteria for this project is a 100-year storm which is different from the determination of a 100-year flood event under our flood protection evaluation. The 100-year storm is based on a precipitation analysis in the localized area.

4. EPA has commented that sufficient information is not provided in the DEIS to determine the reason for eliminating alternatives. The FEIS should indicate whether alternatives were eliminated because they did not provide the <u>maximum</u> hydraulic effectiveness and whether costs were prohibited.

Response: The document has been revised to reflect why various alternatives were eliminated from further study. Alternatives were not eliminated because they did not provide maximum hydraulic effectiveness. Alternatives were eliminated based upon hydraulic effectiveness and because they were not as effective as those alternatives carried forward. Also, certain alternatives were not as costly as the selected plan but were less economically efficient and therefore were eliminated.

<u>Specific Comments</u>

1. The FEIS should provide a table showing the alternatives and the acreage of direct and indirect impacts to jurisdictional aquatic and non-jurisdictional wetlands.

Response: Table 8-1 compares the impacts to jurisdictional wetlands for the various alternatives. Tables 8-2, 8-3, and 8-4 list the impacts resulting from various construction activities. Table 8-6 contains a breakdown of impacts to the various habitat types which may occur as a result of development over the next 100 years. No additional information has been included in this chapter discussing direct and indirect impacts to wetlands. It is also important to note that as development is proposed in the future, evaluations will be conducted in accordance with laws and regulations in force at that time.

2. The level of current flood protection for the study was not clear. Appendix B of the Feasibility Report (FR Appendix B pages 12, 2b) states that the City of West Sacramento has a 90-year level of flood protection, while the Feasibility Report (FR page 26) states there is 70-year level of protection. The FEIS should

clearly state the current level of flood protection for the area in both FEMA and COE terms.

Response: The 70 year frequency addressed on page 26 of the Feasibility Report deals with the frequency of the 1986 flood, not the level of protection. The 90 year level of protection referred to in Appendix B - Comparison of Flood Measures, refers to information developed during reconnaissance level studies to determine the existing level of protection. Further analysis more accurately refined the original estimate. The actual existing level of protection for West Sacramento is approximately 70 years. This report does not address FEMA criteria. It is analyzed solely on Corps criteria as was the American River watershed Investigation.

3. Appendix B of the Feasibility Report uses a 50-year project life for the evaluation of benefits and costs. The project should be evaluated based on a project life of 100-years. The FEIS should show how the economic analysis for each of the alternatives is affected by the change in project life.

Response: The cost information presented in Appendix B and summarized in Table 6 was developed for the Sacramento Metropolitan Area Reconnaissance Report and is provided to inform the reader as to why some preliminary alternatives were dismissed from further consideration. ER 1105-2-100 guidelines state that the period of analysis is the time required for implementation plus the lesser of (1) the period of time over which any alternative plan would have significant beneficial or adverse effects or (2) a period not to exceed 100 years. It was determined for the purposes of the Reconnaissance Study that 50 years was a sufficient period of time to meet the criteria for project implementation and adverse impact analysis. The final Feasibility Report and EIR/EIS presents information based on the 100-year period of analysis because it was subsequently determined that in order to fully analyze the environmental impacts the 100-year period of analysis would be required. This is consistent with other ongoing flood control studies. Appendix B has been revised to clarify this point.

4. The FEIS should evaluate whether the levee base can be increased or other mechanisms used (e.g. cutoff walls) to reduce wetland impacts. It is not clear whether the levee width is proposed in order to allow for minimum crest width of 20-feet.

Response: Increases to the width of the levee base are determined by the levee geometry (crest width and sideslopes) and by the amount of levee raising required. Levee geometry is determined by requirements for levee stability and by requirements for maintenance and inspection. The levee crest must be wide enough to safely drive a vehicle on top. In the case of the Sacramento Metropolitan Study, levee stability requires a 20 foot crest width and 1V:3H waterside slopes and 1V:4H landside slopes. This is also

the geometry of the existing levees. Using this geometry, a five foot increase in levee height will cause a 35 foot increase in base width. If economically viable, floodwalls might require less increase in base width. However, for the Sacramento Metropolitan Study, it was determined that adding additional embankment to the top of the levee was more economically viable.

In regards to cutoff walls the purpose of such structures is to reduce or eliminate seepage through a levee. Seepage can create stability problems and cause a levee to be weak. Seepage is not a problem with the Yolo Bypass levees. Cutoff walls do not increase the level of flood easements and do not decrease flood risk to existing development.

Water quality and Endangered Species

1. EPA has stated that in order to comply with the 404(b)(1) Guidelines, the proposed project must not violate water quality standards, toxic effluent standards, or jeopardize the continued existence of federally listed species or their critical habitat (40 CFR 230.10(b)). The proposed project may result in adverse impacts to federal and state threatened and endangered species such as the valley elderberry longhorn beetle and Swainson's hawk. In addition, the state listed, federal candidate species the giant garter snake may be significantly affected by indirect impacts of the project (i.e., increased development). Close coordination with the U.S. Fish and Wildlife Service (USFWS) and California Department of Fish and Game should ensure the continued existence of the valley elderberry longhorn beetle, giant garter snake, and Swainson's hawk is not jeopardized by the proposed project and that potential impacts to sensitive species are minimized.

Response: Appendix D 404(b)(1) Evaluation and Chapter 11 have been revised to clearly indicate the status of coordination with the State and Federal Endangered Species Acts.

Significant Degradation

1. The COE does not clearly state the level of direct and indirect impacts to wetlands. Potential impact values which are presented in the Feasibility Report, DEIS and Appendices are inconsistent, describing direct impacts to wetlands of 11.9 to 40 acres and indirect impacts of 81 to 1233 acres. The FEIS should consistently reflect the potential impacts to wetlands and other resources.

Response: The project will impact a total of 11.9 acres of wetland and adjacent riparian vegetation as a result of the levee raising. The mitigation requirement for this impact was determined as a result of coordination with the Fish and Wildlife Service. To

compensate for this loss 39.4 acres of wetlands and 13.1 acres of upland habitat will be created from an existing agricultural field inside the Yolo Bypass.

2. The COE states that toe drains should be backfilled if they are within 50-feet of the levee toe (FR Appendix E page 6). Although the COE does not currently believe that toe drains will need to be relocated, they have committed to additional supplemental documentation if relocation is found to be required (DEIS page 8-5). This future documentation should include an alternative analysis, acreage of impact, habitat type to be lost, and proposed mitigation.

Response: The Corps concurs with EPA's request.

3. The FEIS should address in more detail the impacts associated with use of the borrow sites. In addition, the borrow material should be tested for contaminates and the results reported in the FEIS. The borrow site evaluation should describe potential alternative sites if the proposed sites prove unsuitable.

Response: The preferred borrow site is located within the Sacramento Bypass which is isolated from potential sources of contaminants. However, the soils will be tested during PED, prior to being used. If the material is found to be unsuitable, a new site will be selected and tested. This area would be discussed in an Environmental Assessment and circulated for review and comment to concerned agencies, organizations, and individuals prior to being used for construction material.

Mitigation

1. Although EPA commends the COE for their commitment to full mitigation for direct impacts, EPA is very concerned that the COE does not plan to support mitigation for indirect impacts. These indirect impacts are expected to be substantial. We believe actions should be taken at this time to help avoid or compensate for these indirect losses. EPA is concerned that evaluation of potential impacts of future development on a project by project basis may result in unmitigated losses. We are also concerned with the major disparity between the USFWS and COE potential impact and mitigation findings. We urge the COE to work with the USFWS, State and local sponsors to fully address mitigation for indirect impacts of the project.

Response: The Corps is committed to full mitigation for direct impacts on significant resources. The Corps has identified throughout the EIS/EIR indirect impacts associated with the project. Both indirect and cumulative impact mitigation is the responsibility of the non-federal sponsor and local planning agencies. The primary reason mitigation for indirect impacts is

the responsibility of the non-federal sponsor and local agencies is that it is these very agencies which have the responsibility for determining the rate and extent of such growth inducing impacts. In regards to EPA's request that action be taken now to avoid or compensate for indirect losses or impacts it is the Corps contention that there is a high degree of uncertainty associated with growth inducing or secondary impacts. These predicted impacts may never occur in the future on they may be more adverse than predicted. Up-front mitigation of indirect and cumulative impacts provides no guarantee of satisfying the interest of mitigation, that is to provide no net loss of environmental values. Actual impacts may vary drastically from predicted indirect impacts.

The State of California, Reclamation Board is engaged in ongoing negotiations with various environmental agencies with the purpose of developing a mitigation plan for indirect impacts to the Swainson's Hawk in West Sacramento. A summary of these ongoing negotiations is included in the EIS/EIR.

Regarding EPA's concerns with the disparity between USFWS and COE potential impact and mitigation findings, the Coordination Act Report contains impact projections by FWS that consider a greater amount of development and its impacts or fish and wildlife resources. At this point in time, it is difficult to completely and accurately predict where the growth will occur or the extent of such growth; though, it is not inforseeable that development will never exceed the present adopted plans.

Specific Comments

1. EPA's mitigation goal is no net loss of in-kind acres, functions, and values for aquatic habitats. Habitat types that should be created in the mitigation site include riparian forest, emergent marsh, and scrub/shrub habitat. The DEIS indicates that the amount of each habitat type to be created will be determined during the project design stage. Utilizing the wetland delineation, the COE should be able to determine at this time the habitat types which will be lost and must be replaced through mitigation. The FEIS should clearly describe the acreage of each habitat type to be included as mitigation.

Response: The project will impact a total of 11.9 acres of wetland and adjacent riparian vegetation as a result of the levee raising. The mitigation requirement for this impact was determined as a result of coordination with the Fish and Wildlife Service. To compensate for this loss 39.4 acres of wetlands and 13.1 acres of upland habitat will be created from an existing agricultural field inside the Yolo Bypass.

2. EPA is concerned with the potential use of mitigation Site C. Site C has been used for dredge spoils and should be evaluated for

contamination. Furthermore, the FEIS should address the location of future dredged disposal sites and potential impacts to these sites, if Site C is no longer available for dredge disposal.

Response: Area C has been deleted from further consideration for use as a mitigation area. Therefore, no additional information needs to be added to the document.

3. It is unclear whether water is available for mitigation Site D. A mitigation site should be able to function naturally, without long term reliance on pumping or irrigation features for the water supply. The FEIS should also include more information on the long-range development proposed for Site D which is alluded to in the DEIS (DEIS page 8-12).

Response: The proposed mitigation area is located adjacent to existing irrigation and drainage ditches which contain water most of the year. In addition, the area will receive water during storm events when water enters the Yolo Bypass. Because the mitigation area is located in the Yolo Bypass, any proposal for development will require a permit from the Reclamation Board.

4. EPA recommends that plants to be impacted by the proposed project be salvaged for replanting at the mitigation site.

Response: Elderberry plants provide habitat for the threatened valley elderberry longhorn beetle. Therefore, elderberry plants which will be impacted will be transplanted to the mitigation site and/or cuttings will be taken from the impacted plants and propagated on the mitigation site. However, this approach is not practicable for all species impacted. These other species will be planted on the mitigation site from native stock or propagated from cuttings or seeds from native stock.

5. EPA encourages the COE and project sponsor to consider the avoidance measures suggested by the USFWS in their Draft Coordination Act Report (DEIS Appendix B page 81). These measures would help reduce impacts to fish and wildlife and reduce mitigation requirements and costs.

Response: The recommendations contained on page 81 and 82 of the CAR deal with fish and wildlife enhancement and the Corps will continue to pursue them with the non-Federal sponsors as the project continues.

6. The FEIS should provide more information on the rationale for using primarily aquatic related species to evaluate upland impacts in the HEP (DEIS page 10-2.).

Response: The text has been revised to more clearly present the rational for using primarily aquatic related species to evaluate upland impacts. See revised text (Table 10-1), Chapter 10.

7. The DEIS Appendix D 404(b)(1) Water Quality evaluation, states under the cumulative effects determination that most effects would be temporary, minor, or within acceptable limits (DEIS Appendix D page 11). Although effects of the proposed project may be temporary or minor, there are a number of large flood control projects being proposed for the Sacramento area. Potential cumulative impacts could be significant, as clearly stated in the DEIS (DEIS page 1-6). Appendix D should be revised to accurately evaluate the cumulative impacts of the proposed project.

Response: Appendix D has been revised to more appropriately address cumulative impacts.

General Comments

1. DEIS Appendix D 404(b)(1) Water quality Evaluation, states that there are no wetlands within the project area (DEIS Appendix D page 10). This statement is in direct conflict with information in the Feasibility Report (FR page 71) and DEIS (DEIS PAGE 8-3) which clearly states there will be a loss of 11.9 acres of wetlands caused by direct project impacts. The FEIS should explain this discrepancy.

Response: Appendix D has been revised to address the impacts to wetlands which will be affected by the proposed work.

B. Floodplain Management

1. The DEIS indicates that the Elkhorn area, located north of the current study area, was initially included in the Sacramento Metropolitan Area study. Analyses based on existing development indicated that alternatives to increase this area's level of flood protection were not cost-effective and therefore infeasible. As a result, in coordination with the local sponsor and concurrent with local progress towards future development of the area, the COE has transferred the Elkhorn area to the Yolo Bypass Reconnaissance Study to provide sufficient time for the local sponsor to provide information on future development and the potential for additional benefits that could be used in cost-benefit analyses (DEIS page 2-5).

Although EPA supports the protection of existing property and structures from flood damage, they are concerned with the appropriateness of the above action given the direction to Federal Agencies by Executive Order 11988, Flood Plain Management, to avoid direct or indirect support of flood plain development wherever there are practicable alternatives. The FEIS should clearly demonstrate that the transfer of the Elkhorn area to a later project and reevaluation of cost-benefit analyses has not

encouraged future development in order to qualify the area for federally supported increased flood protection.

Response: The Corps does not support flood control development based solely on benefits achieved by future development. The local sponsor requested this area to be viewed separately and a sensitivity analysis on future development completed as part of the investigation. Proposed future growth for the Elkhorn Slough area includes the development of 224 acres as a proposed industrial and commercial park off I-5. The I-5 Metro Project is still in a preliminary stage. At present, the area is under a moratorium which ends in November of 1992; hence, development may not occur without flood proofing until the moratorium ends. Development seems unlikely since the Environmental Impact Report has not been finalized or approved in the General Land Use Plan for Yolo County. Average annual damages and benefits are estimated in accordance with ER 1105-2-100. The analysis assumes that the American River and the Sacramento Metropolitan area projects are in place. Therefore, the Corps policy is in accordance with 11988.

Air Quality

1. The FEIS must clearly demonstrate that the proposed action would not delay timely attainment of NAAQS or contribute to violations of the NAAQS.

Response: The discussion in Chapter__ (Air Quality) has been revised to address this issue.

2. The DEIS does not provide supporting evidence that proposed alternatives meet the conformity requirements of the 1990 Clean Air Act Amendments Section 176 (c)(1).

Response: There is no basis for making a conformity finding.

Assessments of Air Quality Impacts

A. The DEIS does not provide a substantive analysis of whether the projected direct and indirect impacts will interfere with expeditious attainment of national ambient air quality standards or contribute to standards violations in the Sacramento Valley. Nor does the air quality evaluation address the issue of fine particulate matter (PM10). The air quality analysis should address the cumulative effects on air quality expected from development identified to occur once flood protection is provided to the City of West Sacramento.

1. The analysis should discuss potential changes in population, employment, vehicle miles traveled, and additional trips taken. Transportation projects proposed as mitigation for transportation impacts should be accompanied by an analysis of their potential

impacts on air quality, particularly where these projects might induce development in other parts of the region. These transportation projects should be part of a conforming transportation plan.

2. The analysis should project potential emissions increases in carbon monoxide (CO), hydrocarbons (HC), particulate matter (PM10), and NOx resulting from increased population, increased vehicle miles traveled, added trips, as well as added point and area sources of air pollutants.

3. The analysis should also discuss the ozone impacts resulting from increased emissions of HC and NOx and identify CO hot spots in consultation with the local agencies. It should further discuss the impacts of the NOx and SOx emission increases on the related ambient air quality standards.

Mitigation of Impacts to Air Quality

1. The COE should develop with local agencies a mitigation plan to ensure conformity with the Clean Air act. The memorandum of understanding (MOU) proposed for the American River Watershed Investigation project may serve as a model instrument for developing this mitigation plan. The MOU portion for air quality mitigation should be expanded to include Yolo, Solano, Placer, and El Dorado Counties in addition to Sacramento and Sutter Counties. EPA is willing to work with MOU participants to develop a mitigation plan and to ensure that mitigation measures are implemented.

Response: Because project construction is occurring in nonattainment areas, Chapter 7 threats construction-related impacts on air quality as significant unavoidable impacts even though these impacts will be of a temporary short-term nature.

With respect to indirect impacts in the floodplain portion of the project area, the discussion in Chapter 7 makes two points. First, the project improvements will affect the location but not necessarily the magnitude of growth in the metropolitan area. Thus, an incremental increase in emissions of the precursor compounds which create ozone is likely to occur with or without the project.

Second, even is indirect impacts are measured from an existing condition (1992) baseline, the growth facilitated by the project under currently adopted general plans is anticipated by the air under currently adopted general plans is anticipated by the air quality attainment plan recently adopted by the Sacramento Metropolitan Air Quality Management District (SMAQMD). Adherence to this plan would create sufficient offsets in developed areas to permit planned growth to occur in undeveloped areas, without

sacrificing the goal of reducing the inventory of regional emissions to levels which comply with federal and State standards.

General Comments

1. There are minor typographical errors and inconsistencies throughout the document.

Response: Comment noted, text revised where appropriate.

2. EPA believes there may be evidence to document windfall benefits and the need for special cost sharing arrangements.

Response: Projects that provide land enhancement benefits of unconscionable magnitude to a few beneficiaries are subject to special cost sharing. This category of benefits are known as windfall benefits. Location benefits are claimed on approximately 1,400 acres, and 83% of this acreage is owned by 16 landowners. However, these landowners are not the only beneficiaries of the proposed flood control project. There are approximately 12,000 acres within the study area with a population of about 28,000. There are currently over 10,600 residential structures valued at over $580 million. Even though there are 16 landowners who may at some future time benefit financially from a Federal project in West Sacramento, there are many people who would benefit from the flood protection. Accordingly, it is believed that special cost sharing due to locational advantages is not appropriate for West Sacramento.

3. The FEIS description of the Bureau of Reclamations (BOR) multi-purpose Auburn dam project should include information in the current actions and studies being undertaken on this project.

Response: Text revised to reflect current status of BOR studies.

4. EPA recommends the Feasibility Report include a list of the local flood control projects which the report assumes will be in place under without project conditions.

Response: There are currently no local flood control projects in West Sacramento.

5. The Feasibility report appears to utilize two standards for determining levee failure. For instance, the hydraulic damage analysis (FR page 53) assumes failure on encroachment of the water surface halfway into the design freeboard while volume-frequency curves assume no levee failure until design flows have been exceeded (FR page 48). The final Feasibility Report should indicate whether these two assumptions are the same or justify the use of different assumptions.

Response: Failure assumptions used in the report varied according to the location of the levees and the reasons for determining failures. In the area above the confluence of the Sacramento and Feather Rivers, levee failures were determined to calculate the impacts to flood volumes and to determine the magnitude of flood flows which would flow out of the confluence area and down to the economic study area (West Sacramento). In this area, levees were assumed to fail once the existing design discharge was exceeded. This assumption was based on the fact that the Sacramento River Flood Control Project Evaluation Study is currently underway to ensure that the existing levees will pass at least the existing design discharges. To assume any larger flows could pass out of this area would overstate the flood problems in the economic study area. This is the failure scenario described on page 48 and is prudent and factual for determining flood flows into the study area.

In the economic study area, failure determinations should not be at too low a frequency because this would also overstate the flood problem and inflate the benefits. In this area existing levee conditions were considered as well as historic flood levels. Based on this investigation, failure was not assumed to occur until flows had encroached into one-half the current design freeboard. Again this is a prudent determination for determining the existing flood problem and economic benefits in the economic study area. These are the failures discussed on page 53.

6. The COE should provide specific information on the season, year and meteorological conditions under which fish, wildlife, and endangered species surveys were made. Also indicate the number of surveys conducted and the general methodology used.

Response: Surveys were conducted as part of the Habitat Evaluation Procedures (HEP) during the spring and summer of 1989. Meteorological conditions were warm to hot and dry. Field surveys to locate elderberry shrubs, habitat for the threatened Valley elderberry longhorn beetle, were conducted in August and December of 1991. The weather was hot and dry, and cold and dry, respectively.

ER 91/1101

Colonel Laurence R. Sadoff
District Engineer
U.S. Army Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

Dear Colonel Sadoff:

The Department of the Interior has reviewed the Draft Feasibility Report and Environmental Impact Statement/ Environmental Report (DEIS/DEIR) for the Sacramento Metropolitan Area, California Report. The following comments are provided for your consideration when preparing the final documents.

General Comments

Draft Feasibility Report

1 Since the project study area has undergone many changes, several major sections of the DEIS/DEIR need to be clarified. The discussions and displays for the selected plan study area should be clarified. A more detailed justification for separating the various flood control investigations on the Sacramento River system is recommended over using a more programmatic approach that would address cumulative impacts and mutual opportunities.

2 The DEIS/DEIR indicates that the Yolo Bypass, American River Watershed, and Sacramento Metropolitan Area Investigations are closely interconnected and interdependent. Since many of the actions being considered have potential to cause downstream impacts to the Sacramento River and Sacramento-San Joaquin Delta system, the bounds and constraints on the investigation should be clearly explained.

3 Since indirect impacts are anticipated, specific examples of mitigative measures should be provided. The DEIS/DEIR needs to show the site specific areas that would be protected or set aside for fish and wildlife purposes. Commitments for recreational enhancement opportunities need to be made as they are presented.

4 Since all three final action alternatives under evaluation may cause significant unavoidable and unmitigated fish and wildlife habitat losses, the U.S. Fish and Wildlife Service (FWS) does not consider any of these to be environmentally preferred. Inclusion of positive net fish and wildlife benefits in at least one of the action alternatives would enable the DEIS/DEIR to offer a wide array of choices and a better perspective on all the environmental opportunities within the project.

5 In view of the Army Corps of Engineers (Corps) policy to mitigate for indirect impacts and that approximately 8,000 acres of agricultural lands would likely remain without the project, the DEIS/DEIR needs to address why entire mitigation responsibility for indirect impacts has been placed on local sponsors. At present, these lands are being used for farming, internal drainage, fish and wildlife habitat, hunting and fishing, and other recreational use.

Without Federal funding, development on these lands and the resulting loss of agriculture and fish and wildlife habitat probably would not occur. Since the major impacts of the project would be indirect, some alternatives should consider protection of the urbanized portions of West Sacramento and leaving

the agricultural lands intact. This could be accomplished by using ring levees or cross levees at strategic locations.

6 Please clarify the acquisition of additional flowage easements on the west side of the Yolo Bypass should not be considered part of the project. If these easements are being acquired to accommodate 100- or 200-or 400- year level flood stages in the Yolo Bypass, then these flood stages represent an upgrade which should be considered part of the project. Since acquiring additional flowage easements may affect fish and wildlife future habitat evaluations and may present potential mitigation opportunities, they should be addressed.

7 The impacts resulting from both stationary function of south cross levee and its removal should be addressed. However, the cause and effect relationships for the failure and slipout of West Sacramento levees during the 1986 flood need to be clarified. Presently, it is unclear whether wave action, high velocity, long-term inundation, poor maintenance, or some other factors were the main cause for levee failure.

8 Since non-structural options usually provide the least environmentally damaging and often the more desirable fish and wildlife enhancement opportunities, their dismissal in the preliminary flood control alternatives should be reevaluated.

9 The economic cost to benefit ratios appear to be the principal criterion for determining project feasibility. Since the economic analysis is the main criterion for project feasibility, the DEIS/DEIR should provide a complete explanation of the benefits and costs evaluation. The with- and without-project features should be compared to show changing values over time and how flood control, or lack thereof, influences costs and benefits.

Draft EIS/EIR

10 Overall the DEIS/DEIR is well prepared. It provides pertinent and useful information for decision making. Additional information is needed to support the tentatively selected plan. Specific reasons should be given for dismissal of those alternatives not carried forward for evaluation. The discussion on indirect impacts mitigation needs further discussion. Some specific examples of proposed mitigative measures that have been implemented for similar projects should be given.

11 Additional discussion on cumulative impacts is needed. Since there is close linkage between this project and several others upstream of West Sacramento, actions taken on the upstream projects such as the Yolo Bypass Reconnaissance Study and others may have cumulative impact on this project.

12 The FWS is concerned about the potential impacts of this project on the federally threatened valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*). The DEIS reports there are elderberry (*Sambucus* sp.) plants in the project area which are the host for the beetle. Thus, the FWS would have to consider that "take" of the beetle would occur if any of these plants are damaged or destroyed. Because the project site lies within the range of the beetle and suitable host plants are present, the proposed project area should be surveyed by a qualified entomologist to determine the significance of any impacts and to formulate necessary mitigation measures.

13 Potential indirect and/or cumulative effects of the proposed project on the federally listed valley elderberry longhorn beetle outside of the project area have not been adequately addressed in the DEIS/DEIR. Specific areas that should be addressed include areas located south of Highway 80 in the Yolo Bypass and along the Sacramento River.

14 The giant garter snake (*Thamnophis gigas*) is found in the project vicinity. Although the DEIS/DEIR states that suitable habitat exists on site and this species likely inhabits the project site, no studies were conducted to survey for this species. The FWS has proposed a rule to list the giant garter snake as an endangered species. A notice of a proposed rulemaking to list this species as an endangered species should be published in the Federal Register in the very near future. The entire project site should be surveyed by a qualified herpetologist.

15 Potential impacts to the candidate tricolored blackbird (*Agelaius tricolor*) need to be addressed in the DEIS/DEIR. Its population has undergone a dramatic decline in status in recent years. Although candidate species are not protected, the 1988 amendments to the Endangered Species Act require the FWS to monitor the status of candidate species. Adequate surveys should be conducted.

Specific Comments

Draft Feasibility Report

Page 1, paragraph 4. Descriptive terms used such as high level of flood protection and high risk need to be clearly defined early in the discussion. Otherwise they provide little information of substance.

Page 2, paragraph 3. The original design needs to be specified.

Plate C. More than one mitigation site is indicated but not shown.

Page 7, paragraph 2. A map should be provided showing how this project fits within the Sacramento Flood Control System.

Page 7, paragraph 3. This paragraph needs to describe the south side levees.

Page 12, paragraph 6. As stated, this paragraph says that only the Auburn site could provide 200-year or greater protection. This seems unlikely as there are other potential damsites that could conceivably provide this level of protection.

Page 15, paragraph 1. The bounds should be clearly stated, i.e., the incorporated area of West Sacramento or some other specific known bounds.

Page 15, paragraph 3. The specific date when Fremont Weir was constructed should be given. This would give the reader a better perspective on the rate of sediment buildup at the weir.

Page 17, paragraph 6. This paragraph is unclear. The federally threatened valley elderberry longhorn beetle is known to occur in the project area. Elderberry plants (habitat for the beetle) occur along the levees in several locations.

Page 19, paragraph 3. Although, the remaining riparian vegetation along the Sacramento River is important for passive recreation, such as wildlife observation, and general aesthetics, it could be of much greater importance with improved management. The remaining riparian bands are very narrow in many places due to development and levee maintenance practices. A concerted effort by local planners and project sponsors is needed to expand the riparian corridor.

Page 21, Table 2. Based on Plate 4, it appears that hazardous sites referenced as #3, #7, #8, and #9 are within the project study area. This conflicts with the Table 2 information which only indicates site #8 as present.

Page 22, paragraph 3. Those projects committed and those proposed should be identified.

Page 23, Table 3. A footnote explaining the criteria for vacant vs. agricultural lands is needed. Also a breakout of vacant vs. agricultural acreages would be useful.

Page 26, paragraph 2. The specifically planned or perceived level of flood protection that West Sacramento had prior to the 1986 flood should be stated. Use of the term "high level" needs to be specifically defined.

Page 34, paragraph 4. This discussion points out the need for regional flood control planning rather than localized planning. It seems more appropriate to look at the entire flood basin and flood control facilities to accomplish the most effective and efficient flood control.

Page 35, paragraph 1. The expected quantitative occurrence of floods or risk level is more meaningful than the use of the term "serious flood threat." The actual threat needs to be clearly described.

Page 36, paragraph 3. As stated in the FWS' general comments, there are substantial opportunities to improve recreational facilities in the project area. A variety of fish and wildlife resources could be greatly enhanced with better planning and higher goals. The juxtaposition of the Sacramento River, the Ship Channel, large acreages of open space, water conveyance facilities and other resources are key ingredients for enhancing the recreational environment.

Page 37, paragraph 2. An environmentally preferred alternative should be provided in the array of alternatives being studied.

Page 41, paragraph 4. Even though the alternative of setting back levees in the Yolo Bypass was dismissed, setting back levees along the west side of the Yolo Bypass in the vicinity of West Sacramento appears to be a highly desirable environmental alternative. It would provide long-term flood control benefits to the city of West Sacramento and to the public in general. The FWS believes that future growth in the Sacramento Basin may increase the volume of runoff during major storm events. Since the Yolo Bypass is already near capacity, widening should be considered now.

The FWS suggests that a reduction in the flow constrictions of the embankment material under the Southern Pacific Railroad (SPRR) trestle would be considered. Based on a cursory view of Plate #8, it appears that any structural impediment within the Yolo Bypass below the confluence of the Sacramento Bypass would exacerbate flow constriction problems and lower freeboard along the east Yolo Bypass levees. Removing the constriction is more environmentally suitable than riprapping along the east Yolo Bypass levees upstream of the SPRR crossing.

Another measure discussed in early planning focused on widening the Fremont Weir. It would be possible to use the Elkhorn area as a floodway by modifying the levees on the east side of the Yolo Bypass north of Interstate 5. The FWS recommends reconsidering this concept because it could provide substantial fish and wildlife enhancement opportunities.

Page 42, paragraph 2. Additional discussion is needed to explain why 50-year economic evaluations were satisfactory for preliminary evaluation when 100-year economic evaluation were used for the selected plan. In addition, benefits claimed for damaged property should be clarified.

Page 44, paragraph 4. Stating the actual levels of protection included in stabilizing the levees would provide more meaningful data.

Page 43, Table 6. There are several data entries in the Annual Benefit column missing or not quantified. It seems appropriate to include all economic results since some of the data may have led to dismissal of a particular alternative.

Page 46, paragraph 1. Whether the changes in the flow releases from the American River have been considered in this paragraph should be clarified. Since the dry dam at Auburn is considered in place, there may be longer periods with higher sustained flows during major storm events. This could bring the timing of high flows from the American River closer to the peak flow period for the Sacramento River.

Page 46, paragraph 3. This paragraph clearly indicates that the two projects, Sacramento Metropolitan Area Project and American River Watershed Project are closely aligned and interdependent. It is clearly stated that the dry dam at Auburn must be constructed and placed in operation in order to accomplish the 400-year level of protection called for in the Sacramento Metropolitan Area Tentatively Selected Plan.

Page 47, paragraph 1. A map is needed to show where the 23,000 square mile drainage area is located.

Page 48, paragraph 2. A map is needed to depict the scenario presented in this paragraph. Is there more than one cross levee?

Page 48, paragraph 3. There are repeated phrases that need deletion here. Based on this discussion, it appears conceivable that removing the cross levee would provide high damage reduction benefits. Was cross levee removal evaluated as an alternative?

Page 50, paragraph 4. Based on this discussion and earlier ones, it is apparent that wave action is a major cause of levee erosion and possible failure. According to this discussion, constructing levees with more gentle, waterward slopes, i.e., 5 to 1, and increasing the landward berm width help reduce erosion damage. Were these measures considered for the West Sacramento levees north of the Southern Pacific Railroad?

Page 51, paragraph 3. Further discussion on historic sedimentation was not included in appendix D as stated. It should be included.

Page 51, paragraph 5. Since the south cross levee exacerbated flooding levels and damages, an economic analysis of flooding damages should be done without the cross levee in place.

Page 52, paragraph 1. Since the curves from the Tennessee Valley Authority study were prepared more than 20 years ago, are they appropriate for this study? Some further justification is needed. Because the economic benefits essentially determine the feasibility of the project, a clear and concise explanation of the cost/benefit analysis methodology seems appropriate for this section. A brief explanation of how benefits are claimed throughout the period of analysis would be very helpful to the reader. It should be clearly explained how values are placed on structures and how the status of structures is tracked during the project life. An explanation of the methods used to predict timing of and frequency of flooding events that result in damaged property should be briefly described.

Page 54, Figure 6. Explanation of hatch mark symbols used in this figure is needed.

Page 56, paragraph 2. The last sentence refers to display of hydraulic mitigation in Plate 11. There is no such display. This needs correction.

Page 56, paragraph 3. The low benefits calculated for protection of agricultural lands along the west side of the Yolo Bypass imply that damages from added flooding are minimal. This further supports our idea of widening the Yolo Bypass to include these same areas that would be flooded on a more frequent basis anyway. At the same time, the widening would reduce the flood stage along levees on the east side of the Yolo Bypass.

Page 57, paragraph 2. This paragraph clearly states that flooding in areas zoned for agricultural use does not affect either the value or use of the property. This may be inconsistent with the statement on page 51, paragraph 6 which discusses flood damage credits on agricultural lands for farm buildings and crops.

Page 57, paragraph 3. Further explanation is needed to justify this statement. If the 200-year dry dam is in place on the American River and constrains objective releases to 115,000 cfs or less into the lower American River, then some effect seems plausible for the Yolo Bypass. Since flows from the lower American River move upstream in the Sacramento River during high flow events and pass into the Sacramento Bypass, there must be some effect on stage both in the Sacramento Bypass and Yolo Bypass, especially when compared to the 130,000 cfs release necessary in 1986.

Page 60, paragraph 2. This paragraph states that raising the levees around West Sacramento would reduce the probability of levee failure and overtopping. This needs further justification in view of previous statements that suggest erosion caused by wave action was the primary factor contributing to levee failure in 1986. It is conceivable that restoring riparian shrubs and trees along the levees in wave-action trouble spots would reduce and/or eliminate the problem.

Page 62, paragraph 2. Fish and wildlife should also be included in the last sentence.

Page 62, Paragraph 4. This planning guidance needs further explanation. In the previous paragraph you have stated that maximum depth of flooding occurs with a 100-year event discharge, thus it is difficult to understand how any greater damage assessment or damage prevention benefits can be claimed.

Page 67, paragraph 4. Assigning the responsibility for maintenance of the mitigation area to the local sponsor after 3 years is not acceptable to the FWS. The FWS recommends that another agency, such as the California Department of Fish and Game, or a conservation entity, such as The Nature Conservancy, be responsible. Operation and maintenance funding would be provided from the project budget.

Page 67, paragraph 6. Additional explanation is needed regarding levee failure and flood depths. According to the information displayed in Plate 10, flooding depths vary from 3 to 16 feet throughout West Sacramento. This paragraph states that all of West Sacramento would flood to a depth of 16 feet.

Page 68, paragraph 1. As written, this paragraph is inconsistent with previous statements. The plan does nothing to affect Sacramento River flows or flood protection, or reduce damages. Also the plan does not preserve existing environmental resources, since several acres of mature riparian forest would be lost from direct impacts alone. In addition, thousands of acres of existing agricultural lands that also serve as fish and wildlife habitat would eventually be lost. The plan does include mitigation for those direct impacts to riparian forest, but it would take several years before lost wildlife values are regained. More correctly stated, the plan would mitigate for direct impacts and may or may not address future indirect impacts attributable to land use conversions.

Page 68, paragraph 3. Construction design and planning for the cross levee needs much greater attention in the document. There is minimal discussion compared to other levee work and yet this cross levee plays a highly significant role in flooding levels and damage economics. In fact, cross levee design should have been considered as one of the primary preliminary evaluation measures.

Page 72, paragraph 2. The FWS disagrees with the statement that division of habitat types in the plan's mitigation area is not part of the environmental commitment. The results of the Habitat Evaluation Procedures analysis are based on the proportional type of habitats included in the proposed mitigation area, any changes in those types of habitats or proportions of habitats would require reanalysis which could change the results and mitigation requirement.

Paragraph 5. This paragraph and the following paragraph on page 73 are intended to identify indirect impacts as well as potential mitigation. Although 3,400 acres are estimated as lost due to indirect impacts, there are no accompanying mitigative measures discussed. Instead, there is a promise that specific procedures for mitigation would be developed. Some discussion regarding the specifics of the mitigation plan is needed here.

Page 77, paragraph 2. Information in this paragraph needs further explanation. Based on previous text, it is unclear how levee work on the Yolo and Sacramento Bypasses alone can accomplish 150-year-level protection for West Sacramento. According to previous text, minimum freeboard levels planned would be from 4-6 feet. Plate 8 indicates that freeboard levels at two locations along the Sacramento River were less than 4 feet during the 1986 flood. Therefore, it is difficult to understand how the plan would resolve those freeboard problems on the Sacramento River levees unless some work in addition to that described in the plan is completed. If additional work is planned along the west levees of the Sacramento River, it should be described here.

Page 78, paragraph 4. This statement is likely incorrect or needs further clarification. Modification and or raising the cross levee would definitely have some effect on internal drainage during a levee failure or during high rainfall events where internal ponding occurs.

Page 84, paragraph 3. The FWS recommends that maintenance and operation of the fish and wildlife mitigation area(s) be carried out by the California Department of Fish and Game or some other conservation agency approved by the FWS.

Draft Environmental Impact Statement

Page 1, paragraph 4. Of the four mitigation sites under consideration, the site nearest the impact area appears most suitable to effectively regain lost wildlife habitat values. In this particular instance, agriculture is practiced on the site. There may be other sites suitable that would not impact agriculture that have not been identified.

Page 1-7, paragraph 2. Although the Corps recognizes responsibility to mitigate for indirect impacts and the project sponsor would comply with local laws and California Environmental Quality Act requirements, these compliance actions do not represent legally binding specific mitigative measures that would clearly offset the expected future wildlife habitat losses. The FWS recommends that a separate mitigation plan associated with this project, based on the analyses conducted, be developed. The plan should specifically address the fish and wildlife direct and indirect impacts identified and measures to offset those losses.

Page 2-1, paragraph 3. The date that the Yolo Bypass was initially constructed should be given. Which part of West Sacramento is not within the 100-year floodplain should be identified.

Page 2-2, paragraph 3. Under the Corps policy to mitigate impacts, the loss of agriculture and wildlife habitat associated with indirect impacts are included in the environmental cost equation.

Page 2-3, paragraph 4. Further explanation is needed on additional flood control on the American River. It should provide some increment of protection to the western border of West Sacramento. If flood flows in excess of 115,000 cfs occur without additional American River control, then flows into the Sacramento and Yolo Bypass would increase, thus increasing the stage at western border levees.

Page 2-7, paragraph 2. Based on the information in the document, it appears that prior to the 1986 flooding, West Sacramento had less than 100-year level protection. This project would essentially remove West Sacramento from a floodplain and remove any development restrictions that have protected farmland and wildlife in the past.

In our view, this action clearly skirts the intention of Executive Order 11988, Flood Plain Management. The FWS understands the need to protect the existing urbanized portions of West Sacramento, but not the unurbanized portions that are prime farmlands and wildlife habitat. Further, without identifying specific mitigative measures for indirect impacts within the West Sacramento area, any claims to preserving or restoring natural and beneficial values in the floodplain would be unjustified.

Page 3-1, paragraphs 3 and 4. These two paragraphs contradict each other with regards to gate removal. Correction or clarification is needed.

Page 3-2, paragraph 4. It would be helpful to specify the increased level increment.

Page 3-2, paragraph 5. Based on the last sentence, it appears there is adequate space to accommodate additional growth in other nearby areas. This leads us to believe that protecting all of the agricultural lands in West Sacramento may not be urgently needed. Perhaps other alternatives that would preserve and maintain existing farmlands and wildlife habitat should be considered.

Page 3-3, paragraph 4. The FWS supports this change in planning as it would reduce impacts to mature riparian forest.

Page 3-5, paragraph 6. This statement seems to conflict with the one on page 1-7 which states "It is Corps policy to mitigate for indirect impacts". This apparent conflict needs clarification.

Page 3-6, paragraph 2. If there is strong local interest to develop recreation, why has a sponsor not come forward and made necessary commitments? Further explanation is needed.

Page 4-1, paragraph 2. This paragraph needs further explanation. As stated, it not clear why indirect project impacts are not a project responsibility. The given assumption is that without funding, the project would not be built and that with Federal funding, project development would be allowed to proceed in a previously defined floodplain resulting in the eventual loss of thousands of acres of habitat.

Page 4-1, paragraph 3. The proposal to mitigate impacts on an individual, by-project basis is not acceptable to the FWS. Generally this type approach

fails to address all the cumulative, direct and indirect impacts associated with a project. Case-by-case assessments are often because baseline conditions are constantly changing and with-and without project conditions are difficult to discern.

Case-by-case assessments require in-depth regional type analyses and therefore broad and long-term planning opportunities are missed. The FWS does not support the approach of this case unless some previously defined methodology and planning are in place that provide legal guarantees for adequate mitigation.

Essentially, a mutually acceptable mitigation plan is needed that specifies location of lands to satisfy mitigation needs, 2) how those lands would managed in perpetuity, 3) identified responsible managers, 4) funding sources, and mitigation formulas and other similar conditions.

Page 5-2, paragraph 2. This paragraph needs to address the findings with regards to levee instability and capacity for the Sacramento Area.

Page 5-2, paragraph 6. These proposed projects would likely have a large impact on the remaining riparian forest along the Sacramento River. A detailed description and location of the projects are needed.

Page 5-3, paragraph 6. One of the proposed borrow sites is in the upstream end the Sacramento Bypass within the State Wildlife Area. Further discussion is needed about potential impacts, approvals, manner of borrow removal.

Page 5-10, paragraph 3. Review of the sections cited in the West Sacramento General Plan clearly indicate that there are no wildlife protection provisions for non-endangered or threatened species. Although several policies and goals are identified, the Plan clearly states that the rules are guidelines only, subject to feasibility, cost and other decision processes. Therefore, the FWS recommends additional binding agreements to ensure mitigation goals are met.

Page 8-10, paragraph 3. Lost fishery habitat and values would primarily result from the indirect impacts, i.e., conversion of agricultural ponds, drainage ditches, and backwater areas into developed urban areas. Although fishery values in terms of sport fishing are not high, most of the drainage ditches, ponds, and backwater areas support species of fish that are important in the food chain for other fauna such a raccoon, snakes,and fish eating birds. Through careful planning, high fishery values could be obtained along with other emergent marsh, riparian forest and scrub-shrub habitat mitigation efforts.

Page 8-10, paragraph 5. Placing mitigation responsibility on the local sponsor complicates the coordination and reduces the likelihood that mitigation goals would be met.

Page 16-3, paragraph 3. Sport fishing activity should be addressed. Although this activity is not comparable to that in the Sacramento River, it does offer fishing recreation in ponds and drainage ditches for bullhead, sunfish, carp, or other less desirable nongame fishes.

Page 22-3, paragraph 3. There are opportunities to preserve natural floodplains along several of the American Basin foothill streams such as Coon Creek, Auburn Ravine, and Markham Ravine. Setting aside these areas through local planning efforts would accomplish multiple goals including better floodplain management, increasing nonstructural system capacity, increasing acreages of natural lands providing fish and wildlife habitat and beneficial values. Through prudent planning, the need for existing flood control

structural features and likely future flood control structural features could be greatly reduced.

Summary Comments

The 400-year protection level Tentatively Selected Plan focuses on a small part of the vast Sacramento River Flood Control Project which includes about 1,000 miles of levees and affects over 800,000 acres of agricultural lands. This plan is interdependent with the concurrent flood control plan proposed for the American River Watershed because the plan cannot be accomplished, unless the American River Watershed selected plan is implemented.

At the same time these two plans are being considered, other flood control plans in the Sacramento Basin are in various planning stages that would also have some effect on these two plans. In view of the immensity of the area encompassed by the Sacramento River Flood Control Project, and its complexity, we are of the opinion that a much more comprehensive document is needed to describe the far reaching and complex, interrelated nature of the projects being proposed.

Without such a document, ability to assess cumulative, interrelated, and interdependent effects are extremely difficult, if not impossible. With the ever changing project designs and planning efforts for the many ongoing projects, tracking and understanding the future with-project conditions are very difficult if not impossible.

Of the alternatives evaluated in this draft report, the FWS found that none are environmentally preferable. All of them would result in very high adverse impacts to wildlife over the life of the project. However, there are opportunities to mitigate these adverse impacts. The 400-year Plan places the responsibility for mitigating the majority of expected adverse impacts on the local sponsors. At this time, there are no legally binding assurances that the expected adverse impacts would be mitigated.

The FWS recommends that the Corps initiate formal consultation pursuant to Section 7 of the Act to address the potential adverse impacts of the proposed Sacramento Metropolitan Area project to the valley elderberry longhorn beetle. The Corps should also fully address impacts and mitigation for the proposed endangered giant garter snake. In addition, the FWS recommends that the candidate tricolored blackbird species be considered in the DEIS/DEIR.

We appreciate the opportunity to comment.

Sincerely,

Patricia Sanderson Port
Regional Environmental Officer

cc: Director, OEA (with incoming)
Regional Director FWS, Portland

RESPONSE TO DOI COMMENTS

Sacramento Metropolitan Area Study

The following responses are provided in reply to the Department of Interior (which includes the Untied States Fish and Wildlife Service comments) comment and review letter on the Draft Feasibility Report and Draft Environmental Impact Statement/Environmental Impact Report (DEIS/EIR) for the Sacramento Metropolitan Area.

General Comments

Draft Feasibility Report

1. Since the project study area has undergone many changes, several major sections of the DEIS/DEIR need to be clarified. The discussions and displays for the selected plan study area should be clarified. A more detailed justification for separating the various flood control investigations on the Sacramento River system is recommended over using a more programmatic approach that would address cumulative impacts and mutual opportunities.

Response: We concur with the comment regarding the need for clarification of the study area in the DEIS/EIR. The text has been revised to reflect this comment.

In regards to the Department's request for a more detailed explanation for separating the various flood control investigations the following justification is provided.

The Sacramento River Flood Control System consists of several projects which are independent although hydrologically interrelated. It is the Corps contention that these projects because of the physical geography, socioeconomic, and environmental considerations are better evaluated on a separate basis. Each of the proposed project features of the Sacramento River Flood Control System is associated with a separate watershed. Project features on the Yuba River Basin for example, are completely separate from elements in the Sacramento or American River Basins, although each basin is hydrologically inter-related.

In terms of socioeconomic conditions, a prime example, is the degree and rate of urbanization for each of the subareas. The anticipated rate of development, for instance, in the Feather River Basin, is drastically different from that proposed in the Sacramento area. Additional environmental factors such as air quality, transportation, fish, vegetation and wildlife are also unique to the different subareas of the system and as such should be evaluated independently to allow for a more complete and detailed evaluation.

Even though the Corps maintains an independent evaluation of each of the proposed projects provides the most accurate and complete environmental impact evaluation, the agency has not ignored regional cumulative impacts associated with providing flood control to the total system. Each separate EIS/EIR interrelates its particular subarea to the total system in the cumulative impacts analysis of each EIS/EIR.

Based on these factors the Corps feels there is sufficient justification for analyzing the various flood control investigations separately as opposed to providing a programmatic analysis.

2. The DEIS/DEIR indicates that the Yolo Bypass, American River Watershed, and Sacramento Metropolitan Area Investigations are closely interconnected and interdependent. Since many of the actions being considered have potential to cause downstream impacts to the Sacramento River and Sacramento-San Joaquin Delta system, the bounds and constraints on the investigation should be clearly explained.

Response: The Yolo Bypass, American River Watershed and Sacramento Metropolitan Area are closely interconnected and interdependent from a hydrological perspective.

However, these systems can be operated essentially independent of each other so as not to create cumulative hydraulic impacts. In essence, improved flood control conditions within each subarea can be accomplished without adverse hydraulic or hydrological impacts to the other subareas. Therefore, proposed flood improvements for the Yolo Bypass, American River, and Sacramento River will not necessarily result in adverse environmental impacts to the Sacramento River and San Joaquin Delta system.

Recent hydraulic and hydrologic studies indicate that there are no impacts to hydraulic conditions under the Sacramento Metropolitan Study Selected Plan in the Sacramento/San Joaquin River Delta system. Consequently there will be no adverse environmental impacts to these areas. Detailed discussions of the bounds and constraints used in the investigation can be found in appropriate appendices also, see revised text in Chapters 2 and 22 of the EIS.

3. DOI feels that since indirect impacts are anticipated, specific examples of mitigative measures should be provided. The DEIS/DEIR needs to show the site specific areas that would be protected or set aside for fish and wildlife purposes. Commitments for recreational enhancement opportunities need to be made as they are presented.

Response: Under the California State Endangered Species Act, the State is constrained from participating in this project unless local agencies controlling development in the affected areas

provide assurances that they will exercise their authority in such a manner as to avoid jeopardy to any state-listed threatened or endangered species.

In addition, the state, in conjunction with Yolo County, is currently formulating a Habitat Conservation Plan (HCP) to address indirect issues on threatened and endangered species.

Local agencies with land use jurisdiction over the areas in which indirect (growth related) impacts could occur as a result of the project would be responsible for ensuring that mitigation for these impacts is accomplished on a project-by-project basis, as required under applicable State and Federal law.

See Appendices H and I for Memorandums of Understanding between the State of California and local agencies for indirect impacts to fish and wildlife resources including threatened and endangered species.

In regards to recreation enhancement opportunities, a local sponsor has not been identified to date.

4. DOI feels that since all three final action alternatives under evaluation may cause significant unavoidable and unmitigated fish and wildlife habitat losses, the U.S. Fish and Wildlife service (FWS) does not consider any of these to be environmentally preferred. Inclusion of positive net fish and wildlife benefits in at least one of the action alternatives would enable the DEIS/DEIR to offer a wide array of choices and a better perspective on all the environmental opportunities within the project.

RESPONSE: As explained in Chapters 8,9, and 10 there are no unmitigated impacts resulting from the project construction. The corps will continue to work with the non-Federal project sponsors toward creating fish and wildlife habitat as an enhancement feature.

5. DOI states that in view of the Army Corps of Engineers (Corps) policy to mitigate for indirect impacts and that approximately 8,000 acres of agricultural lands would likely remain without the project, the DEIS/DEIR needs to address why entire mitigation responsibility for indirect impacts has been placed on local sponsors. At present, these lands are being used for farming, internal drainage, fish and wildlife habitat, hunting and fishing, and other recreational use.

Without Federal funding, development on these lands and the resulting loss of agriculture and fish and wildlife habitat probably would not occur. Since the major impacts of the project would be indirect, some alternatives should consider protection of the urbanized portions of West Sacramento and leaving the agricultural lands intact. This could be accomplished by using ring levees or cross levees at strategic locations.

Response: The Selected Plan includes requirements to mitigate for direct impacts. Any requirements to mitigate for impacts of induced development will be the responsibility of the local agencies controlling development in the project area. Since the extent and timing of these indirect impacts will be determined in the context of the local land use planning process, it is appropriate that this process address mitigation issues as well. The local government has indicated how they will exercise their planning authority to avoid or minimize indirect impacts associated with future development in their adopted General Plan. The Corps does not believe that it is necessary or appropriate to provide a detailed mitigation plan for indirect impacts in the EIR/EIS.

The Corps does not agree DOI's statement that a high level of flood control could be accomplished by using ring levees or cross levees. In the plan formulation process, some consideration was given to the potential for developing alternatives that would protect urbanized portions of West Sacramento and leaving the agricultural lands intact. However, there are no strategic locations in the vicinity of West Sacramento or Southport to construct cross levees or ring levees which would protect only urbanized areas. Because of the geography of the area raising the existing levees provides a high level of protection to the urbanized area while inclusively protecting the undeveloped areas. A cross levee in the vicinity of the ship channel provides the same protection as the proposed project to the Southport area. A ring levee protecting the Southport area also is not effective since this leaves the urbanized areas of West Sacramento unprotected. Consequently, additional flood control features would still be required for these areas. The most viable alternative to accomplish flood protection is the selected plan.

6. Please clarify why the acquisition of additional flowage easements on the west side of the Yolo Bypass should not be considered part of the project. If these easements are being acquired to accommodate 100- or 200- or 400- year level flood stages in the Yolo Bypass, then these flood stages represent an upgrade which should be considered as part of the project. Since acquiring additional flowage easements may affect fish and wildlife future habitat evaluations and may present potential mitigation opportunities, they should be addressed.

Response: Flowage easements will be acquired by the Reclamation Board to rectify easement deficiencies in the existing flood control project, not to accommodate impacts of this project. It should be noted that flowage easements for occasional flooding are acquired to permit temporary flooding of a specific area and not for the purpose of fish and wildlife enhancement. Lands suitable for fish and wildlife enhancement and/or mitigation are more appropriately acquired in fee as will be the case for the proposed project mitigation.

7. DOI suggests that the impacts resulting from both the stationary function of south cross levee and its removal should be addressed. However, the cause and effect relationships for the failure and slipout of West Sacramento levees during the 1986 flood needs to be clarified. Presently, it is unclear whether wave action, high velocity, long-term inundation, poor maintenance, or some other factors were the main cause for levee failure.

Response: The function of the south cross levee is to complete the levee ring which protects West Sacramento. Specifically, this cross levee prevents flood waters from "backing" into West Sacramento should a failure occur in the levees along the Sacramento River of Yolo Bypass south of the cross levee. The west levee of the Sacramento River at river mile 50 is a low point in the system. The "stationary function" impact of the cross levee is to protect West Sacramento from flooding. When the Yolo Bypass or Sacramento Bypass levees fail and water flows into and through West Sacramento, the south levee will increase ponding levels before these flows flow out of west Sacramento. However, damage occurs to West Sacramento structures as the flows pass through the developed areas even before significant ponding occurs. Examination of the depth damage curves used for determining flood damages and benefits reveals that the largest percentage of damage occurs in the first five feet of flooding. Additional depths of flooding do not appreciably increase damage to most structures. These curves are found in Appendix A of the report. Therefore, removal of the south cross levee would only serve to increase the risk of flooding to West Sacramento and would not appreciable lower flood damages when the Sacramento Bypass or Yolo Bypass levees fail.

In addition DOI has stated that the cause and effect relationships for the failure and slipout of West Sacramento levees during the 1986 flood needs to be clarified. Only a few areas of slope failure were observed in 1986 along the right bank of the Sacramento River from Sacramento Bypass to the south cross levee. These failures were due to high flood levels in the sacramento River. However, subsequent geotechnical analysis determined that several reaches could be unstable at higher flood elevations. These areas are being stabilized by drained berms which are under construction. This work is scheduled for completion in 1992. The Yolo Bypass levees had only 2-3 feet of freeboard during 1986 and waves were washing over the levees at several spots due to inadequate levee heights. No stability problems were observed in the Yolo bypass levees along West Sacramento during the '86 flood. In addition, subsequent geotechnical analysis failed to identify any stability problems in these Yolo Bypass levee reaches. The analysis used for determining levee failure for damage determinations was based on levees becoming unstable at high flood elevations for sustained periods. No historic levee distress of expected failures were identified as caused by inadequate levee maintenance.

8. DOI feels that since non-structural options usually provide the least environmentally damaging and often the more desirable fish and wildlife enhancement opportunities, their dismissal in the preliminary flood control alternatives should be reevaluated.

Response: The 100-year flood plain boundary, established by the Federal Emergency Management Agency, was revised as a result of additional hydrologic data which was developed after the 1986 flood. This revision resulted in all of West Sacramento being located within the floodplain. Approximately 30,000 people live within the flood plain. Relocating this entire population and associated structures is neither socially acceptable nor economically feasible. In addition, it would not be economically feasible to flood proof existing structures. A project which provides a high level of protection is needed to protect existing development and is justified on that basis. Various nonstructural flood damage reduction alternatives were evaluated and are described in the report. The primary conclusion was that these measures would be ineffective due to the great depths of flooding expected and impractical given the significant magnitude of existing residential, commercial, and industrial development in the flood plain. Additionally, as discussed in response to comment no. 5, it is not feasible to provide protection for only the existing development as in the case of developing cross levees or ring levees. These alternatives were discarded as not economically feasible.

9. The economic cost to benefit ratios appear to be the principal criterion for determining project feasibility. Since the economic analysis is the main criterion for project feasibility, the DEIS/DEIR should provide a complete explanation of the benefits and costs evaluation. The with- and without- project features should be compared to show changing values over time and how flood control, or lack thereof, influences costs and benefits.

Response: A complete explanation of the benefits and costs evaluation is presented in Appendix A - Economics. The appendix provides a detailed analysis of with and without project costs and benefits. Damages over time are not provided because future growth is only considered as a location benefit this information presented by decade is provided in Table 13. In addition, it is assumed that if the project is not in place there is no future growth.

Draft EIS/EIR

10. DOI feels that the overall DEIS/DEIR is well prepared. It provides pertinent and useful information for decision making. Additional information is needed to support the tentatively selected plan. Specific reasons should be given for dismissal of those alternatives not carried forward for evaluation. The discussion on indirect impacts mitigation needs further discussion.

Some specific examples of proposed mitigative measures that have been implemented for similar projects should be given.

Response: See revised text in Chapter 4 of the Feasibility Report and Chapter 3 of the EIS which provides additional clarification as to why various preliminary alternatives were not carried forward for further evaluation.

Local agencies with land use jurisdiction over the areas in which indirect (growth related) impacts could occur as a result of the project would be responsible for ensuring that mitigation for these impacts is accomplished on a project-by-project basis, as required under applicable State and Federal law. See Appendix A of the West Sacramento General Plan for proposed mitigative measures for indirect impacts and Appendices H and I for Memorandums of Understanding for indirect impacts.

11. Additional discussion on cumulative impacts is needed. Since there is close linkage between this project and several others upstream of West Sacramento, actions taken on the upstream projects such as the Yolo Bypass Reconnaissance Study and others may have cumulative impact on this project.

Response: See revised text in Chapters 2 and 22 of the EIS/EIR.

12. DOI state that the FWS is concerned about the potential impacts of this project on the federally threatened valley elderberry longhorn beetle (Desmocerus californicus dimorphus). The DEIS reports there are elderberry (Sambucus sp.) plants in the project area which are the host for the beetle. Thus, the FWS would have to consider that a "take" of the beetle would occur if any of these plants are damaged or destroyed. Because the project site lies within the range of the beetle and suitable host plants are present, the proposed project area should be surveyed by a qualified entomologist to determine the significance of any impacts and to formulate necessary mitigation measures.

Response: The project area has been surveyed for elderberry shrubs and mitigation measures have been formulated. See Chapter 11, Section 11.3 of the EIS/EIR for details.

13. DOI feels the potential indirect and/or cumulative effects of the proposed project on the federally listed valley elderberry longhorn beetle outside of the project area have not been adequately addressed in the DEIS/DEIR. Specific areas that should be addressed include areas located south of Highway 80 in the Yolo Bypass and along the Sacramento River.

Response: Impacts to the VELB have been coordinated with FWS in accordance with Section 7 of the endangered Species Act. The mitigation proposed has been confirmed in the Biological Opinion received from FWS.

14. DOI feels the giant garter snake (Thamnophis gigas) is found in the project vicinity. Although the DEIS/DEIR states that suitable habitat exists on site and this species likely inhabits the project site, no studies were conducted to survey for this species. The FWS has proposed a rule to list the giant garter snake as an endangered species should be published in the Federal Register in the very near future. The entire project site should be surveyed by a qualified herpetologist.

Response: Consultation is ongoing with the FWS regarding the proposal to list the giant garter snake as an endangered species. Details are found in Chapter 11 of the EIS/EIR.

15. DOI comments that potential impacts to the candidate tricolored blackbird (Agelaius tricolor) need to be addressed in the DEIS/DEIR. Its population has undergone a dramatic decline in status in recent years. Although candidate species are not protected, the 1988 amendments to the Endangered Species Act require the FWS to monitor the status of candidate species. Adequate surveys should be conducted.

Response: The tricolored black bird is discussed in Chapter 11 of the EIS/EIR.

Specific Comments

Draft Feasibility Report

Page 1, paragraph 4. Revised text. Comment noted.

Page 2, paragraph 3. Revised text.

Plate C. Corrected Plate C.

Page 7, paragraph 2. Revised text.

Page 7, paragraph 3. Revised text.

Page 12, paragraph 6. Revised text.

Page 15, paragraph 1. Revised text.

Page 15, paragraph 3. Revised text.

Page 17, paragraph 6. Revised text.

Page 19, paragraph 3. Comment noted.

Page 21, Table 2. Revised title.

Page 22, paragraph 3. Revised text.

Page 23, Table 3. Agricultural acreage is a subset of vacant lands. Data is not available to develop a specific breakout of vacant lands versus agricultural lands.

Page 26, paragraph 2. Revised text.

Page 34, paragraph 4. Cumulative impacts of flood control projects are discussed in the revised cumulative impacts chapter of the EIR/EIS. This chapter serves to address the regional issues associated with flood protection.

Page 35, paragraph 1. Revised text.

Page 36, paragraph 3. Revised text.

Page 37, paragraph 2. The 404 regulation require the identification of the least damaging, practicable alternative. This has been identified in the EIR/EIS and is among the array alternatives analyzed.

Page 41, paragraph 4. Setting back levees along the west side of the Yolo Bypass in the vicinity of West Sacramento does not effectively provide additional flood protection to the West Sacramento area. Setting back these levees would require relocation of at least 5 miles of levees south of Willow Slough Bypass and does not hydraulically provide effective increased ability to lower stages in the Yolo Bypass. Hydraulic constrictions at the terminus of the Yolo Bypass near the Delta, and at the SPRR and I-80 embankments, limit the ability to discharge additional floodwaters. Setback levees by themselves only provide additional storage area for backwaters. Negligible reductions in flood stages would occur from just by setting back levees.

Consequently in order for setback levees to have any effect these constrictions must also be removed. Removal of constrictions at the SPRR and I-80 embankments were examined during reconnaissance investigations. (Eliminating these constrictions would only reduce water levels 0.5 to 1.0 feet). Costs of accomplishing this range from $140 to $245 million. The west levee costs do not include costs associated with setting back the west levee. The west levee costs would include removal of existing levees, construction of a new levee in excess of 30 feet high, and purchase of additional flood easements on many acres of additional level. Consequently, the costs of this alternative eliminate this alternative.

FWS has also suggested the possibility of using the Elkhorn area as a floodway. This option poses the same hydraulic limitations as setting back levees in the vicinity of West Sacramento. Furthermore, to remove constrictions would impact the Davis water treatment and landfill facilities.

The FWS has also suggested that future growth in the Sacramento basin may increase the volume of runoff during storm events to the point where widening of the Bypass would be necessary. Additional runoff caused by maximum development upstream would not result in significant increases in stage. About 8,000 cfs of additional flow is required to change the flood stage within the Bypass by 0.1 feet. A significant amount of development would be needed to produce this level of increased flow. In addition, because of differences in timing, surface water runoff from developing areas within and adjacent to the study area would generally peak prior to flows coming from the Upper Sacramento River.

Page 42, paragraph 2. The information in Table 6 was developed for the Sacramento Metropolitan Area Reconnaissance Report dated February 1989. The ER 1105-2-100 guidelines state that the period of analysis is the time required for implementation plus the lesser of (1) the period of time over which any alternative plan would have significant beneficial or adverse effects or (2) a period not to exceed 100 years. It was determined for the purposes of the Reconnaissance Study that 50 years was a sufficient period of time to meet the criteria for project implementation and adverse impact analysis. The final Feasibility report and EIR/EIS uses the 100-year period of analysis because it was subsequently determined that in order to fully analyze the environmental impacts the 100-year period of analysis would be required. This is consistent with other ongoing flood control studies for example the American River Watershed Investigation.

In regards to the benefits claimed for damaged property, additional clarification may be found in the Sacramento Metropolitan Reconnaissance Report dated February 1989.

Page 44, paragraph 4. See response to page 2, paragraph 3.

Page 43, Table 6. The alternatives listed in Table 6 were evaluated for their hydraulic effectiveness in reducing flood stages within the Yolo Bypass. Those alternatives that display missing or minimal benefit data did not provide significant flood stage reductions. Therefore, it was concluded that the relative flood control benefits for these alternative would be insignificant.

Page 46, paragraph 1. Text revised. Flows originating from Lake Oroville, Shasta, and Black Butte are the primary causes of peak flows on the Sacramento River as opposed to increased flows on the American River.

Page 46, paragraph 3. Concur.

Page 47, paragraph 1. Revised text. The 23,000 square mile drainage area includes runoff from the Yuba River, American River

and the Eastside Valley Stream.

<u>Page 48, paragraph 2.</u> Revised Plate 1 to indicate a reference to the cross levee.

<u>Page 48, paragraph 3.</u> Text revised to eliminate repeated phrases. The cross levee serves two main purposes: 1) if levee break occurs north of the urbanized area of West Sacramento the cross levee prevents flood waters from flowing into the southern portion of the study area (near Freeport) and 2) if levee failure occurs south of the City of West Sacramento (i.e. River Mile 50) the cross levee prevents water from entering the urbanized West Sacramento area. In addition, if a levee break occurs north of West Sacramento, and the cross levee were to be removed, there is such an extensive volume of water that flood inundation reduction would be minimal. Based on these factors removal of the cross levee was not considered feasible and therefore not evaluated as a possible flood reduction alternative.

<u>Page 50, paragraph 4.</u> Wave action can cause levee erosion and if the erosion is severe enough, it can lead to levee failure. In addition, if waves are high enough, the wave runup on the levee can overtop the levee and cause erosion on the landside slope which could lead to eventual levee failure. Flattening the levee slope can reduce wave runup and slightly reduce wave erosion. However, flattening slopes also increases the base width when the levees are raised, thereby increasing the amount of real estate required, embankment material required, and the environmental impacts of the levee footprint. Flattening of levee slopes was not investigated to determine if it would substantially decrease the amount of levee raising required or to determine if the height reduction would be enough to offset the increase in footprint impact.

<u>Pate 51, paragraph 3.</u> This paragraph does not refer to historic sedimentation but rather to current and expected sedimentation. Part 6 of Appendix D does mention historic sedimentation. However, the purpose of this discussion is to present current sedimentation conditions and how they affect the levee design. Historic sedimentation has no bearing on impacts other than it has partially determined the existing conditions. If detailed information on historic sedimentation is of interest to the comment author, they should refer to the "Sacramento River and Tributaries Bank Protection and Erosion Control Investigation, California, Corps of Engineers, August 1983.

<u>Page 51, paragraph 5.</u> See above response to page 49, paragraph 3.

<u>Page 52, paragraph 1.</u> See revised Economics Appendix A - page 19.

<u>Page 54, Figure 6</u>. Revised text. Corrected Figure 6 page 54.

<u>Page 56, paragraph 2.</u> Text has been corrected. Figure 6 on page

54 depicts hydraulic mitigation features.

Page 56, paragraph 3. See previous response to page 41 paragraph 4.

Page 57, paragraph 2. Text revised. Areas where flood reduction benefits on agricultural lands were claimed are not located in the five areas of hydraulic impact described on page 55.

Page 57, paragraph 3. It is difficult to interpret this comment also, it does not appear to relate to the noted section of the report. The only impact on the Yolo Bypass from proposed the 200-year dry dam is that the objective release flows of 115,000 cfs would be maintained slightly longer than under the existing conditions. The maintenance of 115,000 cfs flows does not impact the stages in the Yolo Bypass because this is the existing condition. The same scenario applies to the Sacramento Bypass since a 200-year dry dam on the American River would not impact the Sacramento Bypass.

Page 60, paragraph 2. The levee failures analyzed in this report are caused by instability resulting from high flow elevations. Even though wave erosion can be a problem, riparian plantings cannot ensure protection. Extensive riparian vegetation already exists along the Tule Canal at the waterside toe of the existing levees. These have not served to substantially reduce wave action. A flood control project must assure protection from the design event. Riparian plantings cannot do this. In addition, it would take many years to establish any substantial riparian growth. Flood protection is needed quickly. Raising the levees with appropriate erosion protection does assure protection in a timely manner.

Page 62, paragraph 2. Text revised.

Page 62, paragraph 4. Greater flood damage benefits are accrued over the 100 year economic life of the project since the 200 and 400-year alternatives protect against the probability of larger flood events occurring during that time frame. For example, under the 100-year alternative protection is not provided against infrequent floods such as the 200 or 400-year events. Consequently average annual benefits of the 100-year alternatives are lower. The depth of flooding which occurs within the flood plain determines the amount of damage that would occur in any particular flood, but does not account for the frequency of occurrence over the economic life of the project. See Economic Appendix A for details of economic benefit calculations.

Page 67, paragraph 4. In accordance with AB 3654 the Reclamation Board is vested with management and control of the Sacramento and San Joaquin Drainage District and exercises various specific and general powers relating to flood control within the district.

Under Section 86-11 of the State Water Code the Sate Board prior to construction at a site of flood control, channel clearance, or bank stabilization project, the board, in consultation with the Department of Fish and Game, shall prepare and adopt a mitigation plan which may be implemented as part of the project. In addition, the Board will designate the agency or agencies responsible for completing and maintaining each mitigation element of the plan.

Page 67, paragraph 6. Text revised.

Page 68, paragraph 1. Text revised. The required mitigation ratio for direct impacts takes into account the time required for lost wildlife values to be regained. In regards to impacts of induced future development it will be the responsibility of the local agencies controlling development in the project area. Since the extent and timing of these indirect impacts will be determined in the context of the local land use planning process, it is appropriate that this process address mitigation issues as well. The local agencies will provide assurances as to how they will exercise their planning authority to avoid or minimize indirect impacts as part of their adopted General Plan.

Page 68, paragraph 3. Text revised. The cross levee will not be raised as part of the proposed plan.

Page 72, paragraph 2. We concur, text revised.

Page 72, paragraph 5. See previous response to comment on Page 68, paragraph 1.

Page 77, paragraph 2. Design freeboard varies for different levees and levee reaches and is discussed in Part 5 Appendix D. Design freeboard for the Sacramento River in the study area is 3 feet. If no additional storage is provided upstream on the American River, flood flows in the American River are large enough to fail levees upstream of its mouth. These failures divert floodflows from the American River. These flow through the City of Sacramento and eventually break levees and reenter the Sacramento River below West Sacramento. In addition, levee failures along the Sacramento River below West Sacramento serve to reduce river elevations in the West Sacramento river reach. For these reasons levee modifications on the Sacramento and Yolo Bypasses by themselves serve to provide substantial flood protection from West Sacramento.

Page 78, paragraph 4. No modification of the cross levee is proposed. See previous response concerning impacts of the cross levee to levee failures. Whatever interior drainage problems which exist today will not be changed by the proposed plan.

Page 84, paragraph 3. See previous response to page 67, paragraph 4.

Draft Environmental Impact Statement

Page 1, paragraph 4. Comment noted.

Page 1-7, paragraph 2. Local agencies with land use jurisdiction over the areas in which indirect (growth related) impacts could occur as a result of the project would be responsible for ensuring that mitigation for these impacts is accomplished on a project-by-project basis, as required under applicable State and Federal law.

Page 2-1, paragraph 3. The Yolo Bypass was initially constructed in 1917. All of the City of West Sacramento is in the 100-year floodplain.

Page 2-2, paragraph 3. As noted here and in Chapter 8, mitigation for indirect impacts is the responsibility of the non-federal sponsors.

Page 2-3, paragraph 4. Significant flood flows in excess of 115,000 cfs on the lower American River without additional American River control would likely cause an American River levee failure. Such a failure would significantly reduce the amount of water reaching the Sacramento and Yolo Bypasses. Consequently, it is unlikely that the river stages along the Yolo Bypass western border levees would increase substantially.

Page 2-7, paragraph 2. The project area was a historically considered a flood plain prior to the original reclamation effort which resulted in construction of the existing levee system. Since completion of the levee system, this area has been prevented from functioning as a flood plain in that the area does not experience periodic flooding on a frequent basis. This area is not considered to be a flood plain as defined under EO 11988.

Page 3-1, paragraph 3 and 4. Revised text.

Page 3-2, paragraph 4. Revised text.

Page 3-2, paragraph 5. The project was designed in accordance with planning principles and guidelines and identifies the NED plan for the alternative which maximizes benefits for each dollar invested.

Page 3-3, paragraph 4. Comment noted.

Page 3-5, paragraph 6. The text on page 1-7 has been corrected.

Page 3-6, paragraph 2. No local cost-sharing sponsor has been identified.

Page 4-1, paragraph 2. It is not Corps policy to mitigate for indirect impacts.

Page 4-1, paragraph 3. Under the State Endangered Species Act, the state is constrained from participating in this project unless local agencies controlling development in the affected areas provide assurance that they will exercise their authority in such a manner as to avoid jeopardy to any state-listed threatened or endangered species.

In addition, the state, in conjunction with Yolo County, is currently formulating a Habitat Conservation Plan (HCP) to address indirect issues on threatened and endangered species. See the response to the department of Fish and Game comment letter for more information on the HCP.

Page 5-2, paragraph 2. Additional information for West Sacramento can be found in Appendix E of this document, for the American River levees in the American River Watershed Investigation geotechnical appendix, and for other Sacramento River flood control system levees in the appropriate documents used for the Sacramento River Flood Control System Evaluation, Phases 2-5.

Page 5-2, paragraph 6. These proposed projects would be on the landward side of the levee along the Sacramento River. These areas are typically devoid of riparian vegetation due to previous disturbances or development. Therefore, impacts would be minimal.

Page 5-3, paragraph 6. The proposed borrow site in the Sacramento Bypass is upstream of the state Wildlife Area. For detailed discussion of potential impacts, and borrow removal see Chapter 8, section 8.2.2.

Page 5-10, paragraph 3. Mitigation for indirect impacts is the responsibility of the local agencies with land use jurisdiction over the areas in which indirect impacts could occur. The Corps encourages the FWS to work with the local agencies to ensure that FWS mitigation goals are met.

Page 8-10, paragraph 3. Fishery values will be obtained through the creation of wetlands and water both on the mitigation site and as a result of other projects such as the Yolo Basin wetlands project.

Page 8-10, paragraph 5. Mitigation for indirect impacts is the responsibility of local government.

Page 16-3, paragraph 3. There will be a minimal reduction in sport fishing opportunities in the drainage ditches. Text revised.

Page 22-3, paragraph 3. Comment noted.

STATE OF CALIFORNIA

PETE WILSON, *Governor*

STATE WATER RESOURCES CONTROL BOARD
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DEC 24 1991

Colonel Laurence R. Sadoff
District Engineer
Department of the Army
U.S. Army Engineer District, Sacramento
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Dear Colonel Sadoff:

SACRAMENTO METROPOLITAN AREA FLOOD CONTROL STUDY: COMMENT ON DRAFT FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT/ENVIRONMENTAL IMPACT REPORT (DEIS/EIR)

Thank you for your November 5, 1991 letter to Governor Wilson regarding the subject DEIS/EIR. Your DEIS/EIR has been referred to the State Water Resources Control Board (State Water Board) for review. Our comments follow:

1. <u>Regulatory Requirements for Water Quality Protection</u>

   a. Pursuant to Clean Water Act (CWA) Section 313, this project is subject to State water quality regulation under the California Porter-Cologne Water Quality Control Act, including the need to obtain Waste Discharge Requirements or a waiver thereof. An appropriate addition should be made to Table 27-1 on page DEIS 27-3.

   b. The discussion on the State Water Board and the California Regional Water Quality Control Board, Central Valley Region, on pages DEIS 24-3 and DEIS 24-4 includes significant errors. We suggest this discussion be revised to read as follows:

      "The State Water Resources Control Board (State Water Board) and the California Regional Water Quality Control Board, Central Valley Region (Regional Board) regulate activities that may affect water quality in the Central Valley. The Regional Board has the primary role in setting water quality standards for receiving waters and for regulating discharges through the issuance of permits to ensure that standards are not violated. The State Water Board formulates statewide policies, approves the Regional Boards' Water Quality Control Plans, and acts as an appeal body for Regional Board decisions on specific projects.

"The type of permit issued by the Regional Board depends on the nature of the discharge. Discharges subject to regulation under Clean Water Act (CWA) Section 402 (point source discharges to surface waters) are permitted through the State's dual regulatory authority under the federally delegated National Pollutant Discharge Elimination System (NPDES) and the California Porter-Cologne Water Quality Control Act (Porter-Cologne Act). Such permits constitute both an NPDES permit and Waste Discharge Requirements (WDRs) as required by the Porter-Cologne Act. Discharges and potential discharges not subject to the CWA are regulated under the Porter-Cologne Act. The requirements include the need to obtain a WDR or waiver thereof.

"If the TSP (400 year alternative) is authorized by Congress under CWA Section 404(r), the project will be exempt from the requirements of CWA Sections 301(a), 402, and 404 and thus would not be subject to NPDES permitting or State Water Quality Certification pursuant to CWA Section 401. The project will, however, still be subject to the requirements of the Porter-Cologne Act."

2. Estimated Impacts and Mitigation Requirements

There appear to be significant differences between the estimates of project impacts and the proposed mitigation presented in the DEIS/EIR and those presented in the U.S. Fish and Wildlife Survey's May 1991 Fish and Wildlife Coordination Report (Coordination Report) for the project. These should be resolved before State regulatory agencies are asked to issue permits for the project. Discrepancies include:

a. Estimated Wetland Losses--The DEIS/EIR indicates about 11 acres of wetland will be directly and permanently affected by the project (Table 8-1, page DEIS 8-3), whereas the Coordination Report (page 65) indicates that construction activities will cause permanent loss of 20 acres of wetland.

b. Proposed Mitigation--The Coordination Report (page 81) recommends the development of a fishery/riparian corridor management plan with specific mitigation components. No reference to such a plan or to many of the recommended components is included in the DEIS/EIR.

c. Risk and Uncertainty Regarding Environmental Mitigation--The Draft Feasibility Report (page 79) indicates that the uncertainty of providing adequate environmental mitigation is low because (1) detailed analysis was coordinated with various agencies, (2) a conservative estimate of impacts was used, and (3) mitigation will be monitored. This conclusion is not supported by the Coordination Report (page 70), which notes that "... land-use predictions ... are a critical element in ... impact assessment .... In our view, the June 1990 land-use analysis prepared by the Corps ... greatly underestimates reasonably foreseeable impacts .... the issue is unresolved ...".

3. <u>Editorial Correction</u>

On page DEIS 6-7, the acronym "(BWQCB)" should be "(RWQCB)".

Thank you for the opportunity to comment on the DEIS/EIR. If we can be of further assistance, please call me at (916) 657-0756. The staff person working on this issue is Oscar Balaguer, and he can be reached at (916) 657-1025.

Sincerely,

Jesse M. Diaz, Chief
Division of Water Quality

cc: Mr. William H. Crooks, Executive Officer
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RESPONSE TO STATE WATER RESOURCES CONTROL BOARD

Sacramento Metropolitan Area Study

1. Regulatory Requirements for Water Quality Protection

a. Pursuant to Clean Water Act (CWA) Section 313, this project is subject to State water quality regulation under the California Porter-Cologne Water Quality Control act, including the need to obtain Waste Discharge Requirements or a waiver thereof. An appropriate addition should be made to Table 27-1 on page DEIS 27-3.

Response: The Central Valley Region of the Regional Water Quality Control Board has informed the Reclamation Board that the waste discharge requirements will be waived.

b. The discussion on the State Water Board and the California Regional Water Quality Control Board, Central Valley Region, on pages DEIS 24-3 and DEIS 24-4 includes significant errors. We suggest that the discussion be revised.

Response: See revised text DEIS Chapter 24.

2. Estimated Impacts and Mitigation Requirements

a. Estimated Wetland Losses--The DEIS/DEIR indicates about 11 acres of wetland will be directly and permanently affected by the project (Table 8-1, page DEIS 8-3), whereas the Coordination Report (page 65) indicates that construction activities will cause permanent loss of 20 acres of wetland.

Response: The difference in acres of wetlands could be attributable to the FWS counting irrigation canals as wetlands. The COE does not recognize these areas as wetlands. The 11.9 acres of wetlands which will be permanently impacted will be fully mitigated by the COE.

b. Proposed Mitigation--The Coordination Report (page 81) recommends the development of a fishery/riparian corridor management plan with specific mitigation components. No reference to such a plan or to many of the recommended components is included in the DEIS/DEIR.

Response: The fishery/riparian corridor management plan is recommended by the FWS to mitigate for indirect impacts. The non-federal sponsor and local agencies are responsible for indirect impact mitigation.

c. Risk and Uncertainty Regarding environmental Mitigation--The Draft Feasibility Report (page 79) indicates that the

uncertainty of providing adequate environmental mitigation is low because (1) detailed analysis was coordinated with various agencies, (2) a conservative estimate of impacts was used, and (3) mitigation will be monitored. This conclusion is not supported by the Coordination Report (page 70), which notes that "... land-use predictions... are a critical element in ... impact assessment... In our view, the June 1990 land-use analysis prepared by the Corps ... greatly underestimates reasonable foreseeable impacts ... the issue is unresolved ...".

Response: The FWS based their land-use on the West Sacramento General Plan. The COE used a more conservative approach based on State of California Department of Finance projections, discussions with local planners, and land availability. See DEIS Chapter 5 for additional details.

3. **Editorial Correction**

On page DEIS 6-7, the acronym "(BWQCB)" should be "(RWQCB)".

Response: Text revised.

State of California

Memorandum

To : 1. Projects Coordinator
Resources Agency

Date : December 31, 1991

2. Ms. Nadell Gayou
Department of Water Resources
1416 Ninth Street, Room 449
Sacramento, California 95814

From : Department of Fish and Game

Subject : Draft Feasibility Report and Draft Environmental Impact Statement/Draft Environmental Impact Report for the Sacramento Metropolitan Area, Yolo County, (SCH 91114004)

The Department of Fish and Game (DFG) has reviewed the Draft Feasibility Report (FR) and Draft Environmental Impact Statement/Environmental Impact Report (EIS/EIR) for the Sacramento Metropolitan Area, Yolo County. This U.S. Army Corps of Engineers (COE) and Reclamation Board sponsored project would afford 100; 200; or 400-year flood protection primarily to the City of West Sacramento, located between the Sacramento River on the east and the Yolo Bypass/Sacramento River Deep Water Channel on the west. All alternatives affect 5.7 miles of existing levees but vary in the degree of protection afforded.

The following comments have been prepared by the DFG as the agency exercising administration over the fish and wildlife resources of California under the authority of and in accordance with the provisions of the Fish and Wildlife Coordination Act (43 Stat. 401, as amended; 16 U.S.C. 661, et seq.). These comments recommend measures for the conservation and prevention of damage to fish and/or wildlife resources of the State.

Numerous State- and federally-listed threatened or endangered wildlife species or species of special concern are present in the project area, including, but not limited to the: giant garter snake, Swainson's hawk, tri-colored blackbird, valley elderberry longhorn beetle, Sacramento anthicid beetle, Sacramento Valley tiger beetle, and California tiger salamander.

Direct environmental impacts of this project are relatively minor affecting 11 acres of riparian forest and 0.4 acres of shrub/scrub habitat and uplands. In compliance with State, and Federal wetland policy, this loss will be mitigated by construction of 39.4 acres of wetland habitats and 13.1 acres of upland habitat.

This project will have significant indirect and cumulative impacts to wildlife by providing additional flood control protection for large portions of the City of West Sacramento General Plan area. This increased flood protection will eliminate Federal Emergency Management Agency (FEMA) restrictions to urban development. The removal of FEMA

restrictions will allow development of 5,473 acres of State-listed threatened Swainson's hawk foraging habitat and will affect numerous other species present in the area as determined by the U.S. Fish and Wildlife Service (FWS).

The COE maintains that impacts associated with this inevitable urban development are the responsibility of local regulators and that the COE is only responsible for the direct impacts of levee and flood control construction. Regardless of responsibility, this project will bring more than 5,000 acres of habitat for State- and federally-listed threatened and endangered species into compliance with FEMA regulations and development will ultimately occur.

Interrelated flood control projects in the Yolo, Sacramento, and Sutter county areas are having a profound cumulative impact on habitat of threatened and endangered species. The Draft EIS/EIR concludes that this project is hydrologically inseparable from other regional flood control projects. For example, implementation of flood control measures identified in the American River Watershed Investigations will provide FEMA compliance and subsequent development of 55,000 acres in the nearby Natomas Basin.

The DFG has determined that implementation of the proposed project will ultimately result in the "take" of State-listed threatened and/or endangered species. The take of a State-listed species is prohibited by Fish and Game Code Section 2080. This includes killing individuals of a listed species, direct or indirect impacts to essential habitat, or negative impacts to reproductive success. Take of a threatened or endangered species may be allowed after consultation with the DFG pursuant to Fish and Game Code Section 2081. This process includes the development of a management plan and implementation agreement entered into between the project proponent and the DFG that would require formalized mitigation to compensate for impacts to the listed species. Similar Federal Endangered Species Act sections (9 and 10a) apply for federally-listed species.

Under the American River Investigation project, the Natomas Basin is currently being analyzed and a Habitat Conservation Plan (HCP) is being formulated to address indirect and cumulative impact issues on threatened and endangered species. The Draft EIR/EIS for the Sacramento Metropolitan Area states (DEIS 11-12 through 11-14) that a HCP should also be prepared for this project and outlines specific mitigation measures. If an HCP were developed and the Memorandum of Assurances as discussed in the DEIS (pages 11-12 through 1-14) were made conditions of project approval in the Final EIR/EIS, the DFG would not object to approval of this project.

In order to comply with Public Resources Code Section 21081.6, a detailed monitoring program must be developed for all required mitigation conditions. The monitoring program should include the following:

1. Specific criteria to measure effectiveness of mitigation.

2. Annual monitoring for a minimum of five years. Annual written reports submitted to the lead agency and the DFG.

3. Annual monitoring reports, each of which include corrective recommendations that shall be implemented in order to ensure that mitigation efforts are successful.

Pursuant to Public Resources Code sections 21092 and 21092.2, the DFG requests written notification of proposed actions and pending decisions regarding this project. Written notifications should be directed to the Department of Fish and Game, Region 2 contact person at the address listed below.

Any work within the 100-year flood plain, consisting of but not limited to diversion or obstruction of the natural flow or changes in the channel, bed, or bank of any river, stream, or lake, will require notification to the DFG as required by Fish and Game Code Section 1600, et seq. The notification (with fee), and subsequent agreement, must be completed prior to initiating any such work. Notification to the DFG should be made after the project is approved by the lead agency. The agreement process should not be used in lieu of specific mitigation measures to be included as conditions of project approval by the lead agency.

This project will have an impact to fish and/or wildlife habitat. Assessment of fees under Public Resources Code Section 21089 is necessary. Fees are payable by the project applicant upon filing of the Notice of Determination by the lead agency.

In summary, the proposed project will have direct impacts on wetland and upland habitats which will be mitigated by creation of new wetland and upland habitat. The project will also have significant indirect and cumulative impacts on the habitat of State- and federally-listed threatened and endangered species. The proposed project will ultimately result in the "take" of State-listed species including the take of essential foraging habitat of the Swainson's hawk. The DFG would not object to

project approval if a specific condition of approval included the development of a HCP and a Memorandum of Assurances detailing specific mitigation requirements for the Swainson's hawk and the giant garter snake.

If we can be of further assistance, please contact Mr. David S. Zezulak, Associate Wildlife Biologist or Mr. Jerry Mensch, Environmental Services Supervisor, Department of Fish and Game, Region 2, 1701 Nimbus Road, Suite A, Rancho Cordova, California 95670, telephone (916) 355-7030.

Howard A Sarasohn for
Pete Bontadelli
Director

cc: Mr David S. Zezulak
Department of Fish and Game
Rancho Cordova, California

Mr. Gary White
U.S. Fish and Wildlife Service
2800 Cottage Way, Room E-1803
Sacramento, California 95825

RESPONSE TO DEPARTMENT OF FISH AND GAME

Sacramento Metropolitan Area Study

Response: The comments from the Department of Fish and Game relate to the following subjects: cumulative impacts, indirect impacts, impacts to listed species and need for a Habitat Conservation Plan, a monitoring plan, Fish and Game code Section 1600 requirements and fees .

Cumulative indirect impacts: These impacts are potentially significant as large areas in the Sacramento area could be protected from flooding by flood control projects under consideration by the Corps and the Reclamation Board. The Sacramento Area Flood Control Agency is currently preparing a Habitat Conservation Plan for the areas in the City of Sacramento and Sacramento and Sutter counties that would be protected by the implementation of the American River Area Watershed Investigation.

Indirect impacts: In order to ensure mitigation to the following resources: cultural and historical resources, wetlands, fish and wildlife resources, endangered and threatened species, and air quality, a Memorandum of Understanding (MOU) Regarding Local Assurances will be negotiated after project authorization by the City of West Sacramento and The Reclamation Board. A draft MOU is included in Appendix I.

Monitoring plan: Section 21081.6 of the Public Resources Code requires that a lead agency adopt a mitigation monitoring plan at the time the lead agency approves the environmental documentation and makes findings on significant impacts and mitigation measured. As this project must be authorized by the U.S. Congress and the California State Legislature, The Reclamation Board, the lead agency under CEQA, will not certify the final EIR, adopt findings or formally approve the project until authorization has been obtained. At that time a monitoring plan will be provided.

Section 1600 agreement: Before construction, the Board will obtain a 1600 agreement from DFG if required.

Fees: The appropriate fee will be paid at the time of the Notice of Determination.

Listed Species: The Reclamation Board intends to include in the Local Cost-Sharing Agreement for the flood control project the Memorandum of Understanding to Establish a Program for the Conservation of Threatened and Endangered Species in Yolo County recently initiated by the County of Yolo and the cities of West Sacramento, Davis, Woodland and Winters. See Appendix H for a copy of a preliminary draft of this document.

COMMUNITY DEVELOPMENT DEPARTMENT

P.O. Box 219 1951 So. River Road, West Sacramento, CA 95691 (916) 373-5854

December 23, 1991

Ms. Susan Ramos
USA Corps of Engineers, Sacramento District
1325 J Street
Sacramento, California
95814-2922

Re: ATTN: CESPK-PD-B - EIS for Sacramento Metro

Dear Ms. Ramos:

In that comments are due on the above draft EIS on December 23, 1991, you have already received these comments by fax on the requested date. This letter is the conforming hard copy of the City of West Sacramento's comments on the proposal. Since the proposal was developed in conjunction with the City and other local interest agencies, we have very few comments about the document. However, the development of the mitigation site for the loss of wetlands does need some further explanation.

1. Site D, EIS pages 1-5, 3-5, & 8-11 et seq., is located in an eddy area easterly of the west end of the Sacramento Bypass and also easterly of the Yolo Bypass (north of the Sacramento Bypass) and RD 900 levees (from I-80 south). As such, the mechanics of the flood flows within this area should be explained or referenced to assure the reader that flood flows will not provide scouring actions which are unique to this eddy.

2. This explanation becomes important should it become evident in the future that a preferential fix is to realign this levee section to provide smooth flood flows. Should this occur, not only would storage capacity be lost, but the wetlands established by this proposal could also be endangered by hydrologic changes.

Rather than establish a wetlands now which may be relocated in the future, it may be preferable to establish the wetlands as an adjunct to other wetlands projects. If this is not practical, a discussion of the requirements to relocate the wetlands, or future assurances, may be appropriate for pages 8-11 et seq.

These points are raised because the City looks forward to continuing to work with the Corps on the development of an accurate model for the Sacramento River basin flood flows. While this project will provide protection from the 400 year storm as we currently anticipate it, there is always the possibility that the continuing efforts will cause us all to reevaluate our perspectives just as the February 1986 storm did.

If you should have any questions about the above comments, please contact me at the CDD office.

Sincerely,

Harry Gibson III

Harry R. Gibson, III
Principal Planner

RESPONSE TO CITY OF WEST SACRAMENTO COMMUNITY DEVELOPMENT DEPARTMENT COMMENTS

Sacramento Metropolitan Area Study

1. The City of West Sacramento has commented that they are concerned that the proposed project mitigation site is located in an eddy area. As such, the mechanics of the flood flows within this area should be explained or referenced to assure the reader that flood flows will not provide scouring actions which are unique to this eddy.

Response: The Corps proposed project will not affect the existing hydraulics of the area. Historically, there has been no scouring of the area associated with flows and/or the existing eddy. The proposed project does not increase flows in the Sacramento Bypass. Therefore, there is no reason to believe that rasing the levees would increase scouring actions. In regards to future events, it is the Corps contention that flood flows associated with the 400-year event would not cause a significant increase in scouring.

2. The City states that the explanation of the mechanics of flood flows within the area is important should it become evident in the future that a preferential fix is to realign this levee section to provide smooth flood flows.

Response: The Corps of Engineers does not consider the realignment of this levee to be a "preferential fix". In the future should the realignment of this levee be proposed by an agency or individual it would require the attainment of a permit from the Reclamation Board, State of California and a Department of the Army Section 10 and 404 permits. These permits would address the issues associated with wetlands removal and/or reestablishment.

CITY COUNCIL:

[illegible]
Lois Wolk, Mayor Pro Tempore
Susie Boyd, Councilmember
Dave Rosenberg, Councilmember
Gerald J. Adler, Councilmember

CITY OF DAVIS 23 Russell Blvd. Davis, CA 95616

U. S. Army Corps of Engineers
Sacramento District
(Attn: CESPK-PD-B)
1325 "J" Street
Sacramento, CA 95814-2922

December 19, 1991

ATTENTION: Susan Ramos, Study Manager

SUBJECT: <u>Sacramento Metro Area Feasibility Report/EIS/EIR</u>

The City of Davis is concerned about the effect of the proposed project on the west levees of the Yolo Bypass and the levees on the lower reach of the Willow Slough Bypass. While the draft report states that implementation of the plan would result in a maximum flood elevation increase of about 0.9 foot, it also states that the risk of flooding is low due to the agricultural use of adjacent lands.

1. It is our concern that other studies underway by the Corps in the Yolo Bypass as well as studies requested by Yolo County on the western tributaries to the Yolo Bypass may indicate the need for additional hydraulic mitigation due to conditions not fully assessed in the draft feasibility report. Because of the proximity
2. of our wastewater treatment facility to Willow Slough, we also see the possibility of losses not accounted for in the risk assessment. Also, no assessment of the risk associated with the County Landfill has been made. This is of concern since Davis, as well as other cities in Yolo County, utilize this facility.

3. The Sac Metro Area project authorization should include provisions for mitigating its impact on restoration and enhancement of the level of flood protection on the west side of the Yolo Bypass. Since the Corps investigations have not been completed, it is not possible for a decision to be made at this time.

Sincerely,

MAYNARD SKINNER
Mayor

DBP:wls
LTR00354.WS

RESPONSE TO CITY OF DAVIS

Sacramento Metropolitan Area Study

1. The City of Davis is concerned that other studies underway by the Corps in the Yolo Bypass as well as studies requested by Yolo County on the Western tributaries to the Yolo Bypass may indicate the need for additional hydraulic mitigation due to conditions not fully assessed in the draft feasibility report.

Response: The Corps feels the feasibility report fully assess the hydraulic impacts and mitigation issues as indicated in the Hydraulic Impact Analysis found in Appendix D - Design and Engineering. Based on this analysis the Corps determined that the proposed project does not significantly impact the existing depth duration or frequency of existing flooding to the area in question. We realize however, this analysis only reflects the impacts of the Sacramento Metropolitan Project. The impacts of ongoing future flood control projects in the vicinity of the area including the Yolo Bypass Reconnaissance Study and the Sacramento Systems Evaluation projects are not known at this time. If significant cumulative impacts are identified when such investigations are completed and potential mitigation features identified, these impacts will be reevaluated during the Pre-Construction Engineering and Design Phase.

2. The City of Davis is concerned that the risk assessment does not take into account the proximity of the City of Davis Wastewater treatment facility to Willow Slough nor does it consider the impacts to the County landfill.

Response: Based upon the information developed under the Yolo Bypass Reconnaissance Study we recognize there is an existing flood threat and potential flood damages to the Treatment Plant and Landfill. The Treatment Plant and Landfill are located in the Willow Slough Bypass area. Both facilities are subject to flooding from potential levee failures on the north Willow Slough Bypass levees. The non-damaging event was assumed to be the 20-year flood event. For the 100-year flood event average depth of overland flow affecting the landfill would be $\leq$ 3 feet and would last for less than 3 days. The landfill appears to be outside the ponding area for this type of flooding. Even considering the above outlined damages potential mitigation measures were not found to be economically feasible.

3. The Sacramento Metropolitan Area project authorization should include provisions for mitigating its impact on restoration and enhancement of the level of flood protection on the west side of the Yolo Bypass. Since the Corps investigations have not been completed it is not possible for a decision to be made at this time.

Response: It is assumed the Sacramento Metropolitan Area proposed

project authorization will not include provisions for mitigating impacts on restoration and enhancement of the land of flood protection on the west side of the Yolo Bypass. As discussed above the area is currently subject to approximately 3-5 feet of flooding under the 100-year event. The proposed Sacramento Metropolitan project could add less than 0.3 foot under the 100-year event and less than 0.9 feet under the 400-year event. Based on this information such impacts would not cause significant additional flooding impacts to the treatment plant and landfill, therefore, the Corps is not recommending hydraulic mitigation.

COUNTY OF SACRAMENTO
ENVIRONMENTAL MANAGEMENT DEPARTMENT
Norman D. Covell, Director, And
Air Pollution Control Officer

SACRAMENTO METROPOLITAN AIR QUALITY MANAGEMENT DISTRICT
Richard G. Johnson, Division Chief

December 5, 1991

U.S. Army Corps of Engineers
Sacramento District, Attn: CESPK-PD-B
1325 J Street
Sacramento, California 95814-2922

Subject: *EIS/EIR For The Sacramento Metropolitan Area, California Study*

Dear Sir or Madam:

Thank you for the opportunity to comment on the above-captioned document. Based on our review, we offer the following comments:

- Page DEIS 7-3. Bullet 1 of Section 7.1.3 states that SMAQMD (District) includes Yolo, Sacramento, portions of Placer and Solano counties. Currently the District contains only Sacramento County. The Connelly legislation creating the District (AB4355, 1988, codified at Section 40950 et sequitur of the Health and Safety Code) allows Placer County, or portions thereof, to join the District if they choose; to date Placer County has not chosen to join the District.

  The last paragraph of Section 7.1.3 (and Section 7.1.2 on Page DEIS 7-2) indicates that it would be difficult to estimate air quality impacts of the proposed project until the District (and ARB) implements and adopts all provisions and regulations mandated by the California Clean Air Act and the Connelly legislation referred to above. The District disagrees. The ability of a project to impact air quality (i.e., emit pollutants) is not dependent upon an agency adopting regulations. The practice of estimating pollutant emissions and their impact on the quality of our air has been long-established.

- Page DEIS 7-5. Table 7-1 indicates that projected emissions from the proposed levee work will increase regional emissions by less than one percent, supporting conclusions in the document that air quality impacts "would likely be insignificant" (Page DEIS 7-4, last paragraph). However, upon recalculating figures shown in Table 7-1, we find that levee work emissions for Total Hydrocarbons (3.73%), NO_X (2.5%), SO_X (8.3%) and Unnamed (assumed to be particulate matter)(8.45%) all exceed the significance criteria threshold of two

8411 JACKSON ROAD, SACRAMENTO, CA 95826 (916) 386-6650
FAX (916) 386-6674

percent given on Page DEIS 7-4. We recommend that the EIS/EIR identify these emissions as significant.

Please contact me at 386-7025 if you have any questions regarding our comments.

Sincerely,

Greg Tholen

Greg Tholen
Associate Planner
Environmental Review Section

c: File ER910924

RESPONSE TO COUNTY OF SACRAMENTO ENVIRONMENTAL MANAGEMENT DEPARTMENT

Sacramento Metropolitan Area Study

1. Page DEIS 7-3. Bullet 1 of Section 7.1.3 states the SMAQMD (District) includes Yolo, Sacramento, portions of Placer and Solano counties. Currently the District contains only Sacramento County. The Connelly legislation creating the District (AB4355, 1988, codified at Section 40950 et sequitur of the Health and Safety Code) allows Placer County, or portions thereof, to join the District if they choose; to date Placer County has not chosen to join the District.

Response: DEIS 7-3 - The text has been revised to reflect that Sutter County has not yet dined the SMAQMD.

2. The last paragraph of Section 7.1.3 (and Section 7.1.2 on Page DEIS 7-2) indicates that it would be difficult to estimate air quality impacts of the proposed project until it would be difficult to estimate air quality impacts of the proposed project until the District (and ARB) implements and adopts all provisions and regulations mandated by the California Clean Air Act and the Connelly legislation referred to above. The District disagrees. The ability of a project to impact air quality (i.e., emit pollutants) is not dependent upon an agency adopting regulations. The practice of estimating pollutant emissions and their impact on the quality of our air has been long-established.

Response: The text has been revised in accordance with this comment.

3. Page DEIS 7-5. Table 7-1 indicates that projected emissions from the proposed levee work will increase regional emissions by less than one percent, supporting conclusions in the document that air quality impacts "would likely be insignificant" (Page DEIS 7-4, last paragraph). However, upon recalculating figures shown in Table 7-1, we find that levee work emissions for Total Hydrocarbons (3.73%), NO_x (2.5%), SO_x (*.3%) and unnamed (assumed to be particulate matter)(8.45%) all exceed the significance criteria threshold of two percent given on Page DEIS 7-4.

Response: The text has been revised to indicate that these impacts are significant.

County of Yolo

625 Court Street, Room 204 Woodland, California 95695 (916) 666-8195

BOARD OF SUPERVISORS

First District — Clark H. Cameron
Second District — Helen Thomson
Third District — George P. DeMars
Fourth Destrict — Betsy A. Marchand
Fifth District — Cowles Mast
Clerk of the Board — Paula M. Cooper

October 25, 1991

Colonel Laurence R. Sadoff
U.S. Army Corps of Engineers
1325 "J" Street
Sacramento, California 95814-2933

Dear Colonel Sadoff:

Subject: Sacramento Metropolitan Area Flood Control Project

It is our Board's understanding that as a result of analyses conducted by the U.S. Army Corps of Engineers in accordance with the Project Guidance Memorandum (PGM), mitigation of the hydraulic impacts from the Sacramento Metropolitan Area Flood Control Project (Project) are not justified. As you know, our Board's position on this matter has been that mitigation must be implemented as an integral part of the Project that causes the impacts.

1. There is a great deal of inequity in the approach outlined in the PGM, which separates mitigation for hydraulic impacts for a benefit cost analysis, and handles the mitigation of impacts to utilities, roads, etc., as part of the feasibility analysis for the entire project. Theoretically, each component of the Project should undergo a separate analysis. Truly, there does not appear to be sufficient justification to construct a project that diminishes the level of protection of one's property because the impacts may seem insignificant, or the present level of protection is already deficient.

2. Since Yolo County's Landfill and the City of Davis' wastewater treatment facilities are of particular concern, our Board would appreciate receiving information that details the impacts to the respective facilities in the event the Yolo Bypass levees were overtopped or failed.

Sincerely,

George P. DeMars

George P. DeMars

cc: Ray Barsch, State Reclamation Board
Ken Ruzich, Reclamation District 900
Larry Gossett, City of West Sacramento
Congressman Vic Fazio

RESPONSE TO COUNTY OF YOLO

Sacramento Metropolitan Study Area

1. The County has commented that there appears to be a great deal of inequity in the approach outlined in the PGM, which separates mitigation for hydraulic impacts for a benefit cost analysis, and handles the mitigation of impacts to utilities, road, etc., as part of the feasibility analysis for the entire project. Theoretically, each component of the Project should undergo a separate analysis. Truly, there does not appear to be sufficient justification to construct a project that diminishes the level of protection of one's property because the impacts may seem insignificant, or the present level of protection is already deficient.

Response: The Corps is not required to complete an economic analysis on potential mitigation measures. However,, the Corps must determine the significance of project impacts in order to decide whether mitigation is required. In the case of the Sacramento Metropolitan Area Study the hydraulic impacts were initially evaluated to determine whether they significantly affected the existing depth, duration and frequency of flooding in the five areas of impact. Our analysis indicated that the proposed Sacramento Metropolitan project did not significantly impact these three factors. A benefit to cost ratio was developed merely to further substantiate our determination of not requiring hydraulic mitigation. The overwriting criteria for determining whether hydraulic mitigation was required was in fact, the "taking analysis". This analysis involved an evaluation of the effects of additional flooding, if any, on land already subject to flooding in the area of the Yolo Bypass, downstream of the proposed project. This analysis pertained to the issue of whether there is additional flooding caused by the project, and if so, does it result in a "taking" within the meaning of the 5th Amendment of the U.S. Constitution, thus necessitating payment of just compensation and acquisition of flowage easements. A "taking" occurs when there is either a physical appropriation of private property or a substantial interference with it which destroys or lessens its value. There must be a substantial interference with the elemental rights growing out of ownership of the property (<u>Harris vs. United States</u> 467 F. 2d801).

In the case of the Sacramento Metropolitan project, the downstream effects on the lands adjacent to the Yolo Bypass, generated to be project features, do not amount to any substantial interference with the present beneficial use of the land. It was determined that there is no significant increase in either the <u>frequency</u>, <u>depth</u>, or <u>duration</u> of flooding during the 100-, 200-, or 400-year events over that which already occurs, such that the beneficial use of the land would be affected.

2. Since Yolo County's Landfill and the City of Davis' wastewater treatment facilities are of particular concern, out Board would

appreciate receiving information that details the impacts to the respective facilities in the event the Yolo Bypass levees were overtopped or failed.

Response: In regards to the County's request for information on the impacts to the Yolo County landfill and the City of Davis' wastewater treatment plant, detailed information including hydraulic studies will be available in the Yolo Bypass Reconnaissance Study scheduled for completion in March 1992. Based upon information developed to date there is an existing flood threat and potential flood damages to both the Landfill and Treatment Plant. Both facilities are subject to flooding from potential levee failures on the north Willow Slough Bypass levees. The non-damaging event is assumed to be the 20-year flood event. A 100-year flood would result in $\leq$ 3 feet of flooding in the area with a duration of less than 3 days. In addition, the landfill appears to be outside the ponding area for 100-year flood. Based on the above damages and depths of flooding potential flood impacts to the facilities were not found to be significant and mitigation measures were not found to be economically feasible.

TELEPHONE
(916) 67.'-5412

7178 YOLANO ROAD
DIXON, CALIF. 95620

IRRIGATION DRAINAGE

RECLAMATION DISTRICT NO. 2068

December 19, 1991

Colonel Laurence R. Sadoff
District Engineer
U.S. Corps of Engineers
Sacramento District
1325 J Street
Sacramento, CA 95814-2922

RE: Draft Feasibility/EIS, Sacramento Metropolitan Area, California

Dear Col. Sadoff:

The subject Report has not adequately addressed the impact of the recommended project on Reclamation District No. 2068.

Your engineers have estimated that the recommended project would increase flood stages at our District as follows:

50-year Flood	No Change
100-year Flood	0.6 foot increase
200-year Flood	0.8 foot increase
400-year Flood	1.1 foot increase

Your report states these impacts are not significant and mitigation is not provided (Page 77). We believe you have not fully considered the impact your project will have on our District.

The northern 0.5 mile of the project levee alignment, north of King Road, within the District boundary along the Yolo Bypass is unleveed. This area was designed by the Corps to contain the design flow of 490,000 cfs without overflowing. The 1986 flood revealed this design assumption to be incorrect. Our District mounted a flood fight along this northern area to keep Yolo Bypass waters from outflanking our project levee in 1986. Higher flood stages resulting from the selected plan would surely cause our levee to be outflanked and District lands flooded. We do not accept your assumption that this outflanking will not increase the depth or duration of flooding to our District. The basis of your assumption that our lands would be flooded from Cache Slough backwater is not substantiated from our experience in 1986, nor substantiated in

the report. Our experience in 1986 indicates that substantial protection is afforded District lands by all units of the Yolo Bypass levee system including the Back Levee along Cache and Hass Sloughs. In addition, substantial improvements were made by the Corp of Engineers by the recent construction of the cross levee within Reclamation District No. 2098.

Our levees have the capacity to contain the 400-year flood with less than project freeboard of 6 feet. In 1986, the flood waters encroached approximately 2 feet into our levee freeboard without levee failure. Therefore, there is a strong possibility your recommended project would cause flows to pass over the unleveed portion of our flood control system, causing waters to be trapped behind the project levees. The mitigation of this flood threat is straightforward. By raising the unleveed part of our flood system to preclude overtopping from the 400-year flood. Otherwise, the selected plan would require a flowage easement over the lands now receiving protection from the project levees.

The second issue we want addressed is the basis for your determination of the required levee height of the selected plan. Did you assume Reclamation District No. 2068 levees failed during your design flood? We do not believe your project should be predicated on the failure of the Reclamation District No. 2068 levee for two reason: (1) the levee may not fail when water is encroached in the freeboard (1986 for example) and (2) our levees may be improved at a later date.

We appreciate the opportunity to comment on your draft report. We are ready to meet with you to discuss the issues raised in this letter and we look forward to your response.

Sincerely,

RECLAMATION DISTRICT NO. 2068

T.M. Hardesty
General Manager

TMH:jdp

c.c. George Basye
Joe Countryman
Raymond Barsch

RESPONSE TO RECLAMATION DISTRICT 2068

Sacramento Metropolitan Study

1. RD 2068 has commented that the subject Report has not adequately addressed the impact of the recommended project on Reclamation District No. 2068.

It is our contention that the subject report does adequately address the issue of hydraulic mitigation. The Corps determined that the northern extent of the flood control levees in the RD 2068 area terminates immediately south of King Road. North of King Road the unleveed portion of the project is controlled by flowage easements. The extent and design of the levees and easements is consistent with the original design requirements for flood control project. The February 1986 peak flow at this location in the Yolo Bypass was estimated to range from 495,000 to 509,000 cfs based upon observed high water marks and adjusted stage rating curves. Based upon stage-frequency relationships the frequency of the 1986 event was estimated to be about 70 years for the Yolo Bypass.

Flood plains delineated for this area indicate some outflanking of the levee for events greater than 70-years. This outflanking would occur under both "with" and "without"project conditions. For the 100-,200-, and 400-year flood events the hydraulic impacts of the recommended project are estimated to be o.6, 0.8, and 1.1 foot, respectively. As flood waters spread overland increased stages would diminish. Therefore, although we agree that there are slight depth, duration, and frequency impacts such impacts have been determined to be insignificant. It should also be noted, that studies indicate that this same area would be primarily impacted by floodwaters originating from the south (specifically from Cache and Haas Sloughs). For further details of this analysis, see Appendix D- Engineering and Design, Hydraulic Analysis Section.

In regards to your question concerning the failure scenario for the Sacramento Study Area the Corps did not assume that the Reclamation District 2068 levees failed.

RECLAMATION DISTRICT 2035
4615 Cowell Blvd.
Davis, CA 95616

December 20, 1991

Colonel Laurence R. Sadoff
District Engineer
U.S. Army Corps of Engineers, Sacramento District
1325 J Street
Sacramento, CA 95814-2922

Re: Comments on Draft Feasibility Report and EIR/EIS for Sacramento Metropolitan Area

Dear Colonel Sadoff:

This letter is in response to the request for comments on the subject draft report investigating flood control alternatives for the area along the Sacramento River and the Yolo Bypass, from the Sacramento Bypass south to approximately Freeport. Upon review of the document, RD 2035 has several concerns that we wish to have addressed.

1. Of primary concern is the relationship between the Sac Metro Study and the other ongoing studies being conducted by the Corps. The Sac Metro, American River, and Yolo Bypass studies appear to be inextricably linked in relation to the function of the Yolo Bypass. We feel that the Corps may be premature in recommending a selected plan that includes Yolo Bypass levee raising prior to appropriate technical analysis of the Yolo Bypass from the Fremont Weir to south of Freeport. RD
2. 2035 feels very strongly that a study incorporating a two dimensional (2D) hydrodynamic model of the Yolo Bypass is the only acceptable analytical method of accurately predicting conditions in the Bypass and impacts during major flood events to lands on both sides of the Bypass and tributaries such as the Knights Landing Ridge Cut, Cache Creek, Willow Slough Bypass, and Putah Creek. Such a study is critical to the long range flood control plans of Yolo County, the communities of Woodland, West Sacramento and Davis, and Reclamation Districts RD 537, RD 785, RD 1600, and RD 2035.

Though the Report does discuss the technical analyses which went into the study, and the analytical models used, we believe the area of study requires a level of sophisticated analysis that can only be provided by a 2D model. This concern is especially important since it was noted in the Sac Metro Report that the selected plan assumes improvements proposed under the Corps' American River Study are implemented, which could further compromise the level of protection provided by the Bypass beyond that which is currently afforded.

RD 2035 is requesting that the Corps immediately undertake a 2D study of the Yolo Bypass and tributary streams. Such a study should be completed before any recommended improvements proposed under the American River Watershed Investigation, Sacramento Metropolitan Area, and Yolo Bypass Reconnaissance studies are implemented. We feel that this study is the only path to answering significant regional flood control issues and should be a concerted goal of the Corps, as well as all affected local governments.

RD 2035 requests that you contact our engineer Mr. James Yost of West Yost & Associates at (916)756-5905 if you have any questions or require additional information.

Sincerely,

Larry Asera

LARRY ASERA
President & Trustee

cc:

Wallace McCormack
Gary Alvernaz
Jim Yost
Fran Borcalli
Jim Egan

RESPONSE TO RECLAMATION DISTRICT 2035

Sacramento Metropolitan Area Study

1. Of primary concern is the relationship between the Sacramento Metropolitan Study and the other ongoing studies being conducted by the Corps. The Sacramento Metropolitan, American River, and Yolo Bypass studies appear to be inextricably linked in relation to the function of the Yolo bypass. We feel that the Corps may be premature in recommending a selected plan that includes Yolo Bypass levee raising prior to appropriate technical analysis of the Yolo Bypass from the Fremont Weir to south of Freeport.

Response: The Yolo Bypass, American River Watershed and Sacramento Metropolitan Area are closely interconnected and interdependent from a hydrological perspective.

However, these systems can be operated essentially independent of each other so as not to create cumulative hydraulic impacts. In essence, improved flood control conditions within each subarea can be accomplished without adverse hydraulic or hydrological impacts to the other subareas. Therefore, proposed flood improvements for the Yolo Bypass, American River, and Sacramento River will not necessarily result in adverse environmental impacts to the Sacramento River and Yolo Bypass and each project can be analyzed independently.

2. RD2035 feels very strongly that a study incorporating a two dimensional (2D) hydrodynamic model of the Yolo Bypass is the only acceptable analytical method of accurately predicting conditions in the Bypass and impacts during major flood events to lands on both sides of the Bypass and tributaries such as the Knights Landing Ridge Cut, Cache Creek, Willow Slough Bypass, and Putah Creek.

Response: The Sacramento Metropolitan Study's hydraulic analysis was based on a dynamic wave computer model which was felt to be appropriate for the Yolo Bypass where back water influences and negative head differences are present. Because of flow and stage complexities, two computer programs were used to model the study area. the HEC-1 Flood Hydrograph Package was used to compute all rainfall-runoff and to route flows in areas where backwater was not a factor. In areas with major backwater influence, negative head differences, and stages caused weir flow, the Dynamic Wave Operational Model (DWOPER) computer program was used to route flows and determine the relationship between stage and flow. Both models were calibrated using the 1983 and 1986 floods. These floods were used because the upstream basins reflected present conditions with all flood control features in operation. The one dimensional model provided sufficient information for the evaluation of levee heights and flood profiles pertaining to the Sacramento Metropolitan Study.

A two dimensional hydrological model will be developed for the Yolo Bypass for the purpose of evaluating proposed projects in the

bypass including the wetlands restoration project and possible future environmental enhancement projects. However, the 2D model will not provide a significantly more accurate evaluation of the Sacramento Metropolitan hydraulic conditions than the one dimensional model base which was used.

sacramento river preservation trust

U. S. Army Corps of Engineers
Sacramento District
1325 J Street
Sacramento, CA 95814-2922
Attn: CESPK-PD-B

December 23, 1991

To Whom It May Concern,

The Trust would like to make the following comments concerning the Draft Feasibility Report and Environmental Impact Statement/Environmental Impact Report (DEIS/EIR) for the Sacramento Metropolitan Area, California Study:

1) How much attention was given to setting levees *back* from their current location, especially on the west side of the Yolo Bypass and below West Sacramento on the Sacramento River?;

2) The discussion on page 41 concerning diversion facilities seems to rule out a potentially viable alternative, especially if the diversion occurs just downstream of West Sacramento. Is the Sacramento-Yolo Port District's position the deciding factor here? If so, when did "potential impacts to ship traffic" take precedence over flood control?;

3) What is the status of the American River Watershed Investigation and its Draft EIS/EIR and how does it interface with this document (they are obviously related, so...)?; and,

4) Considering the size and complexity of the material presented, a longer comment period seems more-than-appropriate. It appears the guiding force here is a congressional deadline concerning flood insurance. Should good planning be driven in this way? We think not and hereby ask for an extended comment period of at least another 45 days.

We look forward to your response to our concerns. Please send all such correspondence to the address on our letterhead.

Sincerely,

John B. Merz
Chair, Board of Directors

cc. Interested parties

P.O. Box 5366, Chico, CA 95927
(916) 345-4050

RESPONSE TO SACRAMENTO RIVER PRESERVATION TRUST

Sacramento Metropolitan Area Study

The following information is provided in response to the Sacramento River Preservation Trust comment letter of December 23, 1991.

1. How much attention was given to setting levees back from their current location, especially on the west side of the Yolo Bypass and below West Sacramento on the Sacramento River.

Response: Setting back levees along the west side of the Yolo Bypass in the vicinity of West Sacramento does not effectively provide additional flood protection to the West Sacramento area. Setting back these levees would require relocation of at least 5 miles of levees south of Willow Slough Bypass. Just setting back these levees, however does not hydraulically provide effective increased ability to lower stages in the Yolo Bypass. Hydraulic constrictions at the terminus of the Yolo Bypass near the Delta, and at the SPRR and I-80 embankments, limit the ability to discharge additional floodwaters. In addition, setback levees by themselves only provide additional storage area for backwaters. Negligible reductions in flood stages would occur from just setting back levees. In regards to setting back the Sacramento River levees below West Sacramento the feasibility study concluded the primary cause of flooding to West Sacramento is from the Yolo Bypass and not from the Sacramento River. Therefore, setting back these levees would not provide additional flood protection to the urbanized area of West Sacramento.

2. The discussion on page 41 concerning diversion facilities seems to rule out a potentially viable alternative, especially if the diversion occurs just downstream of West Sacramento. Is the Sacramento-Yolo Port District's position the deciding factor here?

Response: The diversion alternative that was analyzed as part of the Sacramento Metropolitan Study included diverting a portion of the floodwaters in the Yolo Bypass and/or the Sacramento River into the Ship Channel near the Port by pumps and bypasses. Based on hydrologic information diverting flows of 20,000 to 40,000 cfs into the Ship Channel from the Yolo Bypass side would have only a minimal impact on flood stages in the study area for major flood events. As a result, diversion from the Yolo Bypass side was deleted from further consideration.

Hydrologic modeling efforts did indicate that significant reductions in flood stages for major flood events (similar to the 1986 flood event or larger) could be achieved in the Sacramento River downstream of the American River by diverting excess floodwater from the Sacramento River into the canal via the lock. The costs and problems associated with this diversion are significant. Major Port facilities, such as docks, loading cranes, warehouses, etc., would have to be relocated and/or reconstructed

because new levees would be required on both sides of the Ship Channel adjacent to the Port. During those periods when floodwaters were diverted into the Ship Channel, ship traffic would be impacted. In fact, ship movement would probably cease. In addition, changes in erosion and deposition in the channel would probably increase dredging costs significantly. Because of these costs and problems, the Sacramento-Yolo Port District (who owns and operates the Port of Sacramento) does not support using the Ship Channel as a diversion channel for floodwaters. Because of the increased costs, potential problems and local opposition, the alternative was deleted from further consideration.

3. What is the status of the American River Watershed Investigation and its Draft EIS/EIR and how does it interface with this document?

Response: The American River Watershed Investigation Final Feasibility Report and EIS/EIR has been completed and is currently scheduled to be released for public review by February 1992. The Sacramento Metropolitan Study assumes this project in place under the "with" and "without" project conditions. However, as indicated in the report without the proposed American River project the Sacramento Metropolitan Study Selected Plan would still be a feasible project.

4. Considering the size and complexity of the material presented, a longer comment period seems more-than-appropriate.

Response: The Council on Environmental Quality requires 45 days for public review of environmental impact statements. An executive summary is provided to assist the reader in assimilating the key information in the document. In addition, two public meetings and a public hearing was held in order to further explain the proposed project and to address any comments or concerns. The public will also have an opportunity to comment and review the final report before it is provided to Congress.

JUSTIN ANTHONY KENNEDY
LAND and NATURAL RESOURCES DEVELOPMENT
1450 HARBOR BLVD., SUITE D
WEST SACRAMENTO, CA 95691
(916) 372-7484

VIA FAX (916) 557-7856

December 23, 1991

Col. Laurence R. Sadoff
U.S. Corps of Engineers
District Engineer,
Sacramento District

In my capacity as a consultant to the Swanston family, I and lawyers for the family have reviewed USCE's Sacramento Metropolitan Area Draft Feasibility Report and DEIS/EIR. While the Swanstons support efforts to enhance flood protection for West Sacramento, we were distressed to note that the "Tentatively Selected Plan" locates the Environmental Mitigation Site (Site D) on the Swanston's property adjacent to the east Bypass levee just south of the Sacramento Bypass.

As many USCE staff are aware, the Swanstons are working with the City of West Sacramento, the County of Yolo, and several State and Federal agencies, including USCE, to study the feasibility of urban development within the approximately 550 acres bounded by the Sacramento Bypass, the east Bypass levee, the West Capitol Avenue levee, and the toe drain. Mitigation Site D is located in the center of this area and would be highly incompatible with the land use plans for the property.

The Incremental Analysis of Mitigation Alternatives ("IAMA") states that this "development is not imminent." Our timeline for the development anticipates completion of urban services by 1997. Additionally, the IAMA indicates an acquisition cost of approximately $2,000 per acre. The entire 2,852 acre Swanston Ranch, of which the acreage is in question is a part, is currently under contract to be purchased for a per acre amount significantly in excess of the $2,000 figure. The 550 acres east of the toe drain have an imputed value in the purchase contract of at least $7,500 per acre due to their excellent agricultural production and their potential for urban development.

The Swanstons actively support the Yolo Basin Wetlands concept and believe the mitigation site developed as part of this project should be coordinated with USCE's effort at the Mace Ranch. In

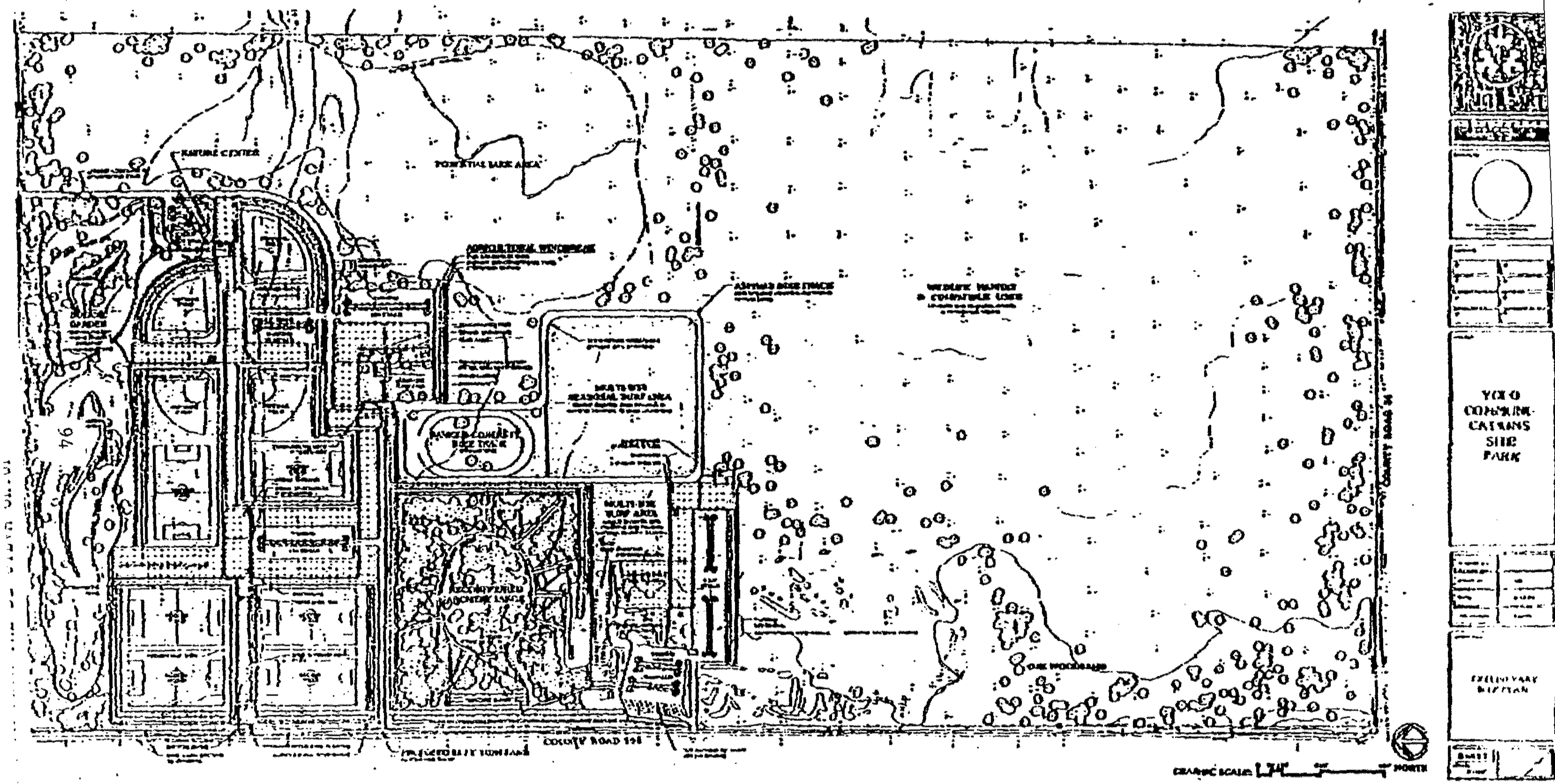
addition, Yolo County officials have offered property for mitigation in conjunction with the County's wetland development program (see attached diagram). If this type of coordination is not possible, the Swanstons would be pleased to sell a seventy acre parcel in any other area of the Upper Ranch or at one of the family's other properties in the Yolo Bypass area.

Thank you for considering the Swanston's concerns with respect to the proposed location of the Environmental Mitigation site. Finding an alternative location would render irrelevant our further questions regarding the breadth and completeness of the alternatives analysis especially in relation to minimizing direct loss of wetlands and riparian habitat.

Sincerely,

Justin Kennedy

cc: Betsy Marchard, Yolo Ctny. Board of Supervisors
Steve Patek, City of West Sacramento
Ken Ruscich, RD 900
George Basey, RD 537
Fran Borcalli
Steve Gidaro
Bert Swanston


NATURE CENTER
POTENTIAL PARK AREA
COUNTY ROAD 98
OAK WOODLAND
GRAPHIC SCALE
NORTH
PARK

RESPONSE TO JUSTIN ANTHONY KENNEDY
LAND AND NATURAL RESOURCES DEVELOPMENT

Sacramento Metropolitan Area Study

In response to Mr. Kennedy's comment letter of December 23, 1991, a project mitigation site is selected primarily on the basis of habitat suitability and proximity to the proposed construction site. If a site is selected, Federal law requires that owners be offered just compensation. Just compensation is fair market value as determined by an appraiser at the time of the offer.

In order for a site to be considered suitable for mitigation for the proposed Sacramento Metropolitan project, the site must be able to support high quality wetlands and uplands habitat. Soil type and availability of water are critical factors which affect site suitability. In addition, adjacent land uses must be compatible so disturbance is minimized and therefore the mitigation site is not likely to become an isolated wildlife habitat surrounded by urban development. Such a scenario could diminish the ability to achieve species diversification.

The proposed Sacramento Metropolitan Site D is representative and meets the critical environmental criteria. However, we recognize that land uses may change and other factors may influence mitigation site selection between the date of the final Feasibility Report and initiation of land acquisition for the project. Therefore, final site selection is a tentative process. In conclusion, we are receptive to suggestions and will continue to explore the suitability of other sites, including the Yolo County site.